ORIGINAL ARTICLE

A comparison of different treatment techniques for posterior crossbite in the mixed dentition

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In this retrospective investigation, the changes occurring during the treatment of patients with posterior crossbite in the mixed dentition with the use of expansion plate and quad-helix appliances were evaluated and compared with those resulting from growth and development occurring in a control group of patients of similar age and type of malocclusion. The expansion plate group consisted of 13 patients, the quad-helix group of 14 patients, and the control group consisted of 10 children with transverse posterior crossbites in the mixed dentition. The research material was formed from orthodontic models and lateral and frontal cephalometric radiographs from 37 children. It was observed in this investigation that transverse expansion is achieved by both the expansion plate and quad-helix appliances. However, the average period of treatment was 1.2 years for the expansion plate, and 0.6 years for the quad-helix appliance. Although posterior crossbite was corrected in a fairly short period of time, the quad helix appliance caused considerable buccal tipping of the maxillary first permanent molars. (Am J Orthod Dentofacial Orthop 1999;116:287-300)

Posterior crossbite is one of the most frequently observed malocclusions of the deciduous and mixed dentition periods. The prevalence of this malocclusion is regarded to be 8% by Kutin and Hawes,[1] and 12% by Hanson et al[2] during the deciduous dentition and 7.2%[1] during the mixed dentition.

Various investigators claim that this abnormality is not self-correcting and they recommend treatment at an early period.[1,3-10] It is noted that treatment of posterior crossbite in the deciduous dentition period can be realized through the grinding of deciduous teeth that cause premature occlusal contact.[6,10-13] The treatment during the mixed dentition period, however, relies on the transversal expansion of the maxillary teeth.

In the treatment of posterior crossbite through the transverse expansion of the maxillary teeth, various appliances such as the coffin spring, expansion plate, "W" appliance, or quad-helix appliances are used.

It was observed that there were no studies analyzing the changes that occur during the treatment of posterior crossbite either with expansion plates or quad-helix appliances using a control group. There exists only one study[14] that deals with the effects of expansion plates and quad-helix appliances in the treatment of posterior crossbites. However, there was no control group in that study.

The aim of this study is to evaluate specific dental and skeletal changes during the treatment of posterior crossbite using expansion plates and quad helix appliances and comparing them with those changes occurring in the control group.

MATERIAL AND METHODS

In this retrospective study, altogether 37 cases with posterior crossbites forming two treatment groups and one control group were treated at the Department of Orthodontics, Istanbul University, Faculty of Dental Medicine.

The following criteria were taken into consideration in the selection of cases for this study: (1) morphologic posterior crossbite on one or both sides due to transverse maxillary deficiency, (2) Angle Class I or Class II molar occlusion, and (3) the mixed dentition period.

As shown in Table I, from among the total number of 37 children, 10 were assigned to the control group, 13 to the first treatment group with expansion plates, and 14 to the second treatment group with quad-helix appliances.

Table II shows the mean ages and the average period of control and treatment of the research materials. As seen in Table II, the control period in the control group consists of two phases, the first phase being 0.5

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Table I. Sample characteristic

	Angle Class I		*Angle Class II*		
	Unilateral posterior crossbite	*Bilateral posterior crossbite*	*Unilateral posterior crossbite*	*Bilateral posterior crossbite*	*Total*
Control group					
Girl	5		1	1	7
Boy	2		1		3
Pooled	7		2	1	10
Expansion plate group					
Girl	11				11
Boy	2				2
Pooled	13				13
Quad-helix group					
Girl	6	5	1		12
Boy		1	1		2
Pooled	6	6	2		14
Total					
Girl	22	5	2	1	30
Boy	4	1	2		7
Pooled	26	6	4	1	37

Table II. Age distribution and length of treatment and control periods (years)

	$\bar{x}$	*SD*
Control group		
Age at the beginning of Stage I	9.4	1.3
Age at the end of Stage I and/or age at the beginning of Stage II	9.9	1.3
Age at the end of Stage II	10.6	1.3
Duration of Stage I	0.5	0.0
Duration of Stage II	0.7	0.2
Duration of Stage I + Stage II	1.2	0.2
Expansion plate group		
Pretreatment age	9.3	1.1
Posttreatment age	10.5	1.3
Duration of treatment	1.2	0.3
Quad-helix group		
Pretreatment age	9.7	1.4
Posttreatment age	10.3	1.4
Duration of treatment	0.6	0.2

$\bar{x}$, Mean value.
SD, Standard deviation.

years and the second 0.7 years, making a total control period of 1.2 years. The treatment period is 1.2 years in the first group treated with expansion plates, whereas that period is 0.6 year in the second group treated with quad-helix appliances.

The materials of this investigation consist of orthodontic models and lateral and frontal cephalometric radiographs taken at the pretreatment and posttreatment periods for the two treatment groups and at the beginning of the control period for the control group, and at the end of the first and second phases. These phases of control group are explained in the statistical analysis section.

PREPARATION OF THE QUAD-HELIX APPLIANCE AND CLINICAL APPLICATION

The quad-helix appliance with a lock and key mechanism used in this investigation was a modification of the "W" appliance developed by Rickets.[15-18] The quad-helix appliance (Fig 1), made of a 0.9 mm stainless steel wire, was activated 1 week after its application. The degree of activation of the appliance was adjusted so as to allow for the retention loop on one side to pass from the central fossa of the first permanent molar when the other retention loop was placed into the lock. The arms of the quad-helix appliance were held parallel to each other when activated (Fig 2). The quad-helix appliance was activated once a month until the posterior crossbite was corrected.

PREPARATION OF THE EXPANSION PLATE AND CLINICAL APPLICATION

Martin Schwartz[17,19] developed the expansion plate used in this investigation. This plate had a midline screw for symmetric expansion and clasps on the teeth (Fig 3). The screw was opened by a quarter rotation every week until the posterior crossbite was corrected.

ANALYSIS OF ORTHODONTIC MODELS

The following measurements were performed as shown in Fig 4 on the orthodontic casts.

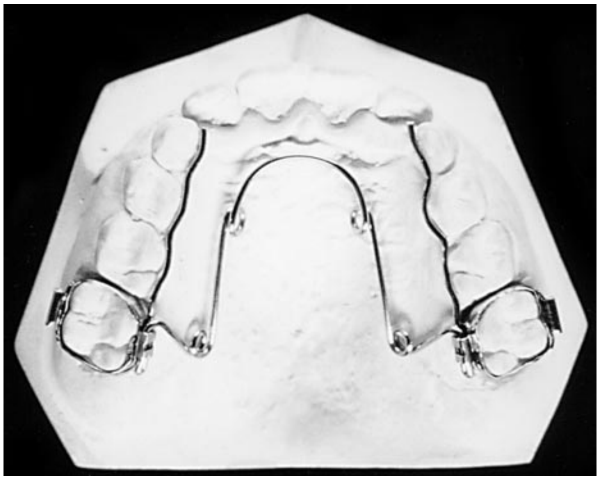

Fig 1. Quad-helix appliance.

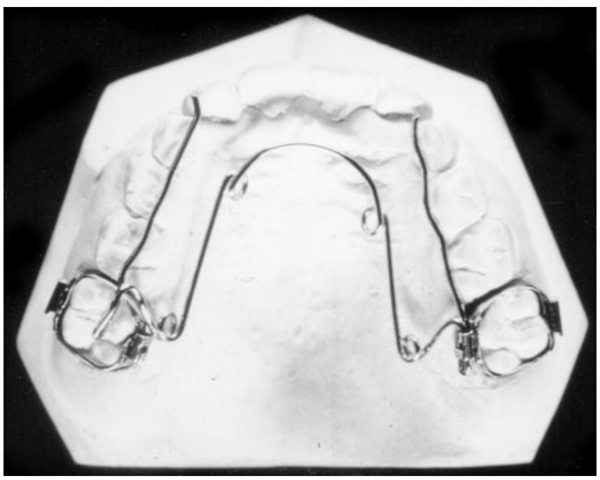

Fig 2. Activation of quad-helix appliance.

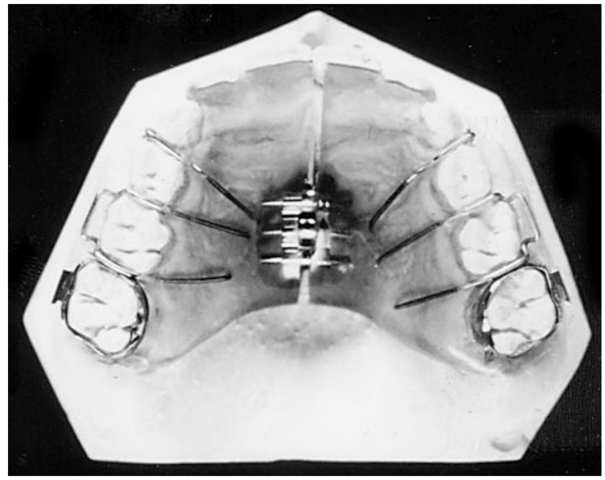

Fig 3. Expansion plate.

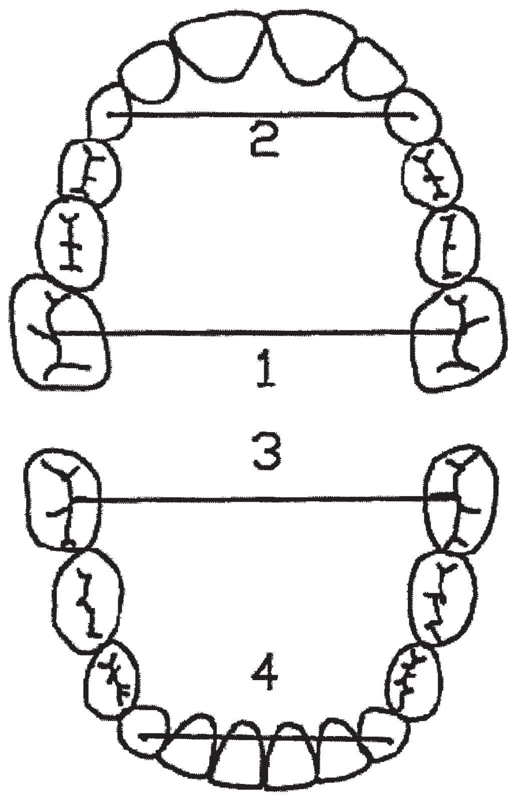

Fig 4. Orthodontic cast analysis: *1*, maxillary intermolar width; *2*, maxillary intercanine width; *3*, mandibular intermolar width; *4*, mandibular intercanine width.

1. Maxillary intermolar width: the width between the central fossae of the right and left first maxillary permanent molars.
2. Maxillary intercanine width: the width between the crown tips of the right and left deciduous or permanent maxillary canines.
3. Mandibular intermolar width: the width between the central fossae of the right and left first mandibular permanent molars.
4. Mandibular intercanine width: the width between the crown tips of the right and left deciduous or permanent mandibular canines.

The measurements were made by a single investigator on the maxillary and mandibular orthodontic models, to the nearest 0.1 mm using sliding callipers.

Because the cases examined in the present investigation were in the mixed dentition period, in some cases the mandibular or maxillary deciduous canines had exfoliated and the permanent canines had not yet erupted. Consequently, the maxillary and mandibular intercanine widths could not be measured in all of the

Table III. Error of the method (Sm) and 95% confidence limits

	Sm	*Upper confidence limit*	*Lower confidence limit*
Orthodontic cast measurements			
1. Maxillary intermolar width	0.17	0.13	0.24
2. Maxillary intercanine width	0.17	0.13	0.24
3. Mandibular intermolar width	0.14	0.10	0.20
4. Mandibular intercanine width	0.16	0.12	0.23
Frontal cephalometric measurements			
5. 6⌋ Axial inclination	0.84	0.64	1.21
6. ⌊6 Axial inclination	0.85	0.65	1.22
7. Maxillary intermolar angle	1.01	0.77	1.45
8. Maxillary apical base width	0.38	0.29	0.54
9. Nasal width	0.53	0.40	0.76
Lateral cephalometric measurements			
10. SNA	0.55	0.42	0.79
11. SNB	0.54	0.41	0.77
12. ANB	0.31	0.23	0.44
13. SN/GoGn	0.45	0.34	0.64
14. Maxillary incisor/SN	1.12	0.85	1.61
15. Maxillary incisor height	0.37	0.28	0.53
16. Maxillary molar height	0.43	0.32	0.62

Table IV. Evaluation of the changes in the control group (n = 10) due to growth and development in a mean of 0.7 year

	Beginning of Stage II		*End of Stage II*		*Difference*		
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{D}$	*SD*	*Wilcoxon test*
Orthodontic cast measurements							
1. Maxillary intermolar width	44.5	2.1	44.9	2.1	0.4	0.3	*
2. Maxillary intercanine width (n = 7)	30.9	2.3	31.6	2.5	0.7	0.5	*
3. Mandibular intermolar width	42.4	2.0	42.5	1.9	0.1	0.2	
4. Mandibular intercanine width (n = 8)	26.1	1.1	26.3	1.1	0.2	0.2	*
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	86.3	4.9	88.1	4.8	1.3	2.0	
6. ⌊6 Axial inclination	85.2	7.4	85.4	7.5	0.2	2.8	
7. Maxillary intermolar angle	8.1	8.9	6.6	7.8	–1.5	3.4	
8. Maxillary apical base width	58.7	2.8	58.8	3.0	0.1	0.2	
9. Nasal width	26.4	2.3	26.8	2.4	0.4	0.3	
Lateral cephalometric measurements							
10. SNA	80.2	4.2	80.2	4.0	0.0	0.4	
11. SNB	75.7	4.1	75.5	4.3	–0.2	0.4	
12. ANB	4.6	2.3	4.7	2.2	0.1	0.6	
13. SN/GoGn	36.9	5.5	37.1	5.6	0.2	0.8	
14. Maxillary incisor/SN	100.5	7.0	100.4	6.8	–0.1	0.7	
15. Maxillary incisor height	25.6	1.6	25.7	1.8	0.1	0.6	
16. Maxillary molar height	18.9	1.4	19.4	1.4	0.5	0.7	
17. Age	9.9	1.3	10.6	1.3	0.7	0.2	

*$P < .05$.

cases. The *n* numbers in the groups belonging to these parameters are shown in Tables IV through XII.

ANALYSIS OF FRONTAL CEPHALOMETRIC RADIOGRAPHS

In order to determine the inclination of the maxillary first molars during the analysis of the frontal cephalometric radiographs, 0.18 × 0.25 inch stainless steel wires, bent into different shapes for the right and left maxillary molars (Figs 5 and 6), were placed into the standard edgewise tubes when the radiographs were taken. These reference wires, prepared for each of the cases, were stored during the investigation period, and the same wires used for each case when other radiographs of the same cases were taken.

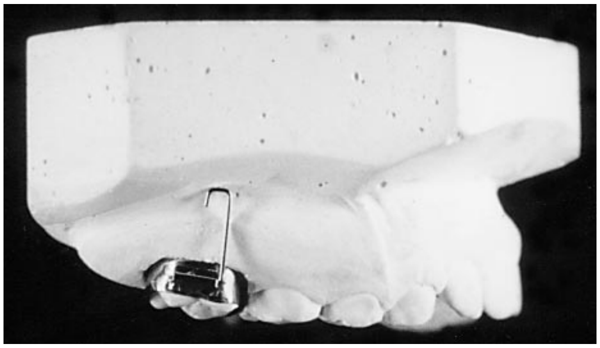

Fig 5. Image of wire prepared from stainless steel and placed on right molar tube.

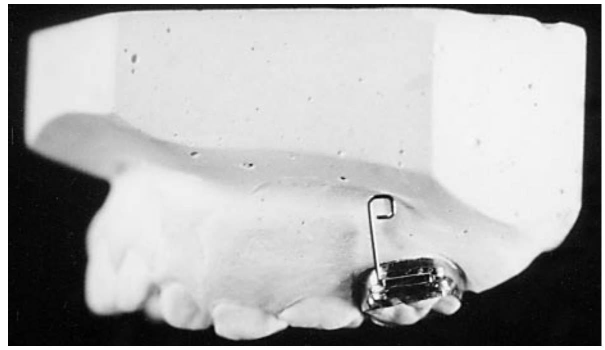

Fig 6. Image of wire prepared from stainless steel and placed on left molar tube.

For the cephalometric analysis of the frontal cephalometric radiographs, the cephalometric points shown in Fig 7 were determined and 3 angular and 2 millimetric measurements were made using these points (Fig 8).

The cephalometric points used in this study have been derived from several frontal cephalometric analysis methods. The explanation for these points was taken from the book by Uzel and Enacar.[20]

ANALYSIS OF LATERAL CEPHALOMETRIC RADIOGRAPHS

In order to analyze the lateral cephalometric radiographs, the 12 cephalometric points shown in Fig 9 were determined and by using these points, 5 angular and 2 millimetric measurements were made (Figs 9 and 10).

The cephalometric points used in this study have been derived from several lateral cephalometric analysis methods. The explanation for these points was taken from the book by Uzel and Enacar,[20] Perkün,[21] and, Salzmann.[22,23]

METHOD ERROR

Twenty randomly selected lateral and frontal cephalometric radiographs were retraced and remeasured and 20 randomly selected orthodontic models were measured for a second time 1 month later to estimate the error that might occur in the measurement and tracing of the lateral and frontal cephalometric radiographs and in the analysis of the orthodontic models. Afterward, the method error for each parameter was calculated, based on the principles as defined by Dahlberg,[24] using the formula given below (Table III):

$$S_m = \sqrt{\varepsilon d^2/2n}$$

where Sm is method error, d is the difference between the first and second measurements, and n is the number of cephalometric radiographs and orthodontic models measured for the second time (n = 20).

After the method error for each parameter had been determined, the 95% lower and upper confidence limits of the real method error were calculated using the formula below (Table III).

$$S_m^2/(x^2 \cdot 0.975/n) < \delta_m^2 < S_m^2/(x^2 \cdot 0.025/n)$$

δ^2 = real method error

x^2 = n degree of freedom of chi-square (n = 20)

As shown in Table III, method error was seen in one angular parameter in each group (parameter 14) and (parameter 7) in lateral and frontal cephalometric radiographic analysis, respectively. The greatest method error was made in parameter 14 of lateral cephalometric analysis, which is 1.12°. The lowest method error was in parameter 3, which is the mandibular intermolar width (0.14 mm).

STATISTICAL ANALYSIS

In this investigation, the values obtained at pretreatment and posttreatment periods for the two treatment groups and for the control group at the start of the control period and at the end of the first and second phases, and definitive values related to the changes that occurred during the treatment and control periods were calculated (Tables IV-XII).

In order to determine the actual changes due to treatment in both of the treatment groups, and to allow for a precise statistical analysis, the control period in the control group was especially adjusted to match the treatment periods in the expansion plate group and the quad-helix appliance group. Consequently, the changes that occurred in 1.2 years in the expansion plate group were compared with those that occurred in the total control period consisting of phase I and phase II, namely 1.2 years. The changes that occurred in 0.6 year in the quad-helix group were compared with those that

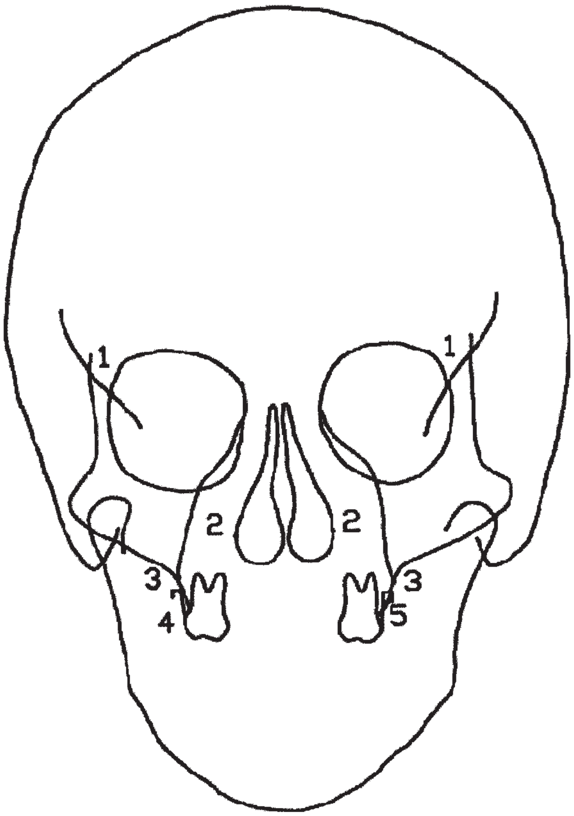

Fig 7. Cephalometric reference points: *1*, “Lo” latero-orbit; *2*, “N” nasal; *3*, “Mx” maxillare; *4*, ⌋ reference line was constructed along lateral aspect of threaded wire placed into tube on maxillary right first permanent molar band and this line shows tipping of this tooth; *5*, ⌊ reference line was constructed along lateral aspect of threaded wire placed into tube on maxillary left first permanent molar band and this line shows tipping of this tooth.

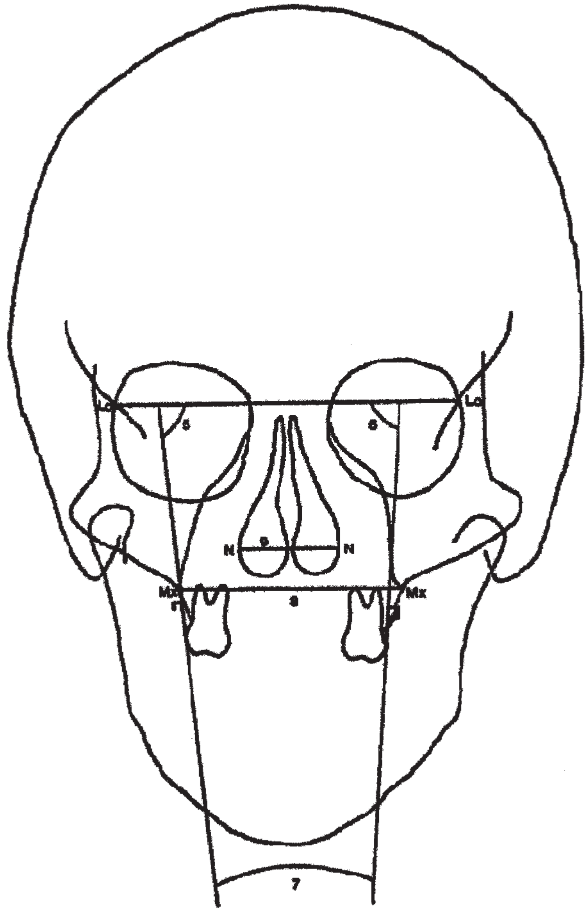

Fig 8. Linear and angular measurements: *5*, 6⌋ axial inclination angle; *6*, 6⌊ axial inclination angle; *7*, maxillary intermolar angle (this angle was taken to be positive when it was below the occlusal surfaces of the first permanent molars and negative when it was above the root apex); *8*, width of the skeletal base of maxilla; *9*, width of the nasal cavity.

occurred in phase II of the control period, in other words, 0.7 year. The reason why phase II of the control period was chosen for comparison is that the mean age at the start of the treatment in the quad-helix group is compatible with the mean age at phase II of the control period (Table II). As far as the comparison of the changes that occurred in the expansion plate and quad-helix groups is concerned, the changes were calculated again in the expansion plate group by reducing the average treatment period, ie, 1.2 years to 0.6 year, which is the average treatment period in the quad-helix group. During the reduction of changes in the expansion plate group from 1.2 years to 0.6 year, the difference between the pretreatment and posttreatment values of each parameter for each individual in each group was multiplied by 0.6 year and divided by the total treatment period of that individual.

In the present investigation, nonparametric methods were used during the statistical analysis and the intragroup comparisons were made using the Wilcoxon test and the intergroup comparisons using the Mann-Whitney test.

RESULTS

Changes in the Expansion Plate Group (Tables VIII-IX)

Table VIII shows the comparison results of the changes in the expansion plate group reduced to 0.6 year and the changes in the control group, phase II (0.7 year). The maxillary intermolar, maxillary intercanine, and maxillary apical base width and the SNB angle increased more in the expansion plate group than in the control group.

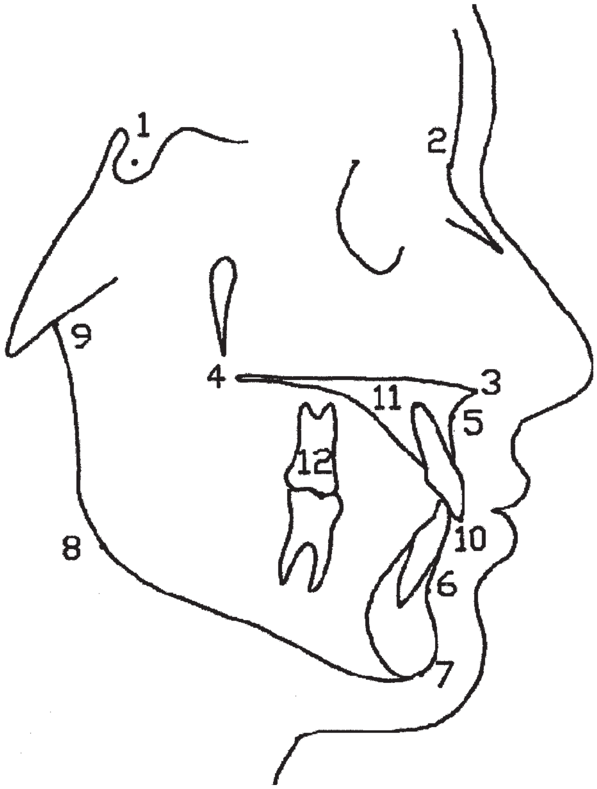

Fig 9. Cephalometric reference points: *1*, "S" Sella; *2*, "N" Nasion; *3*, "ANS" Anterior Nasal Spina; *4*, "PNS" Posterior Nasal Spina; *5*, "A"; *6*, "B"; *7*, "Gn" Gnathion; *8*, "Go" Gonion; *9*, "Ar" Articulare; *10*, most forward incisal point of most prominent maxillary central incisor; *11*, apical point of maxillary central incisor; *12*, tip point of vestibula mesial cusp of maxillary first permanent molar.

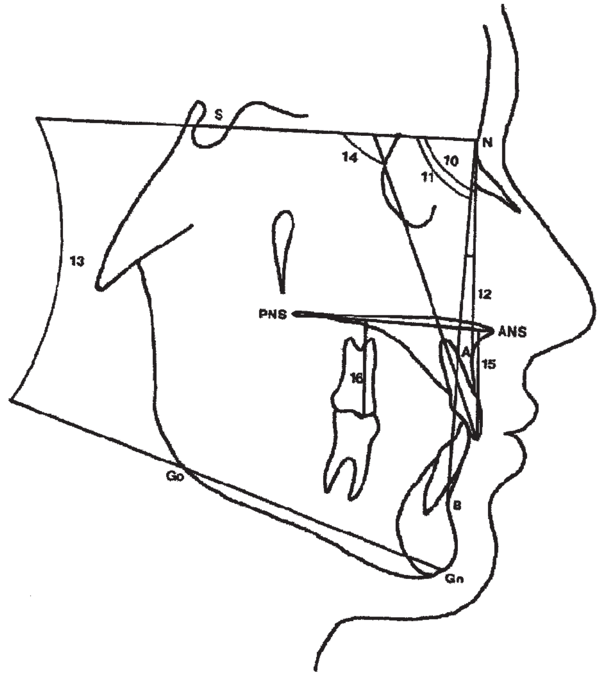

Fig 10. Linear and angular measurements: *10*, SNA angle; *11*, SNB angle; *12*, ANB angle; *13*, SNGoGn angle; *14*, upper 1/SN angle; *15*, upper 1 ⊥ ANS-PNS; *16*, upper 6 ⊥ ANS-PNS.

Table IX, on the other hand, shows the comparison results of the changes in the expansion plate group during the average treatment period of 1.2 years and those in the control group during the total (phase I + phase II) control period of 1.2 years. The maxillary intermolar and maxillary intercanine widths increased more in the expansion plate group than in the control group.

Changes in the Quad-helix Appliance Group (Table X)

Table X shows the comparison results of the changes in the quad-helix group during the average treatment period of 0.6 year and those in the control group during phase II (x = 0.7 year). The maxillary intermolar, maxillary intercanine, and maxillary apical base widths and the axial inclination of the first maxillary molars exhibited a greater increase in the quad-helix than in the control group and a greater decrease was observed in the maxillary intermolar angle.

Comparison of Changes in the Expansion Plate and Quad-helix Appliance Groups (Tables XI and XII)

As seen in Table XI, statistically significant differences were found between the two treatment methods in terms of 5 parameters from among the 16 parameters measured, as a result of the comparison between the changes that occurred in 0.6 year in the expansion plate and quad-helix appliance groups. The maxillary intermolar widths, axial inclination of the maxillary left, and right first permanent molars and maxillary apical base width exhibited a greater increase in the quad-helix group than in the expansion plate group, and a greater decrease was observed in terms of the maxillary intermolar angle.

As shown in Table XII, the comparison of the changes in the expansion plate group during the average treatment period of 1.2 years and those in the quad-helix appliance during the average period of 0.6 year exhibited a statistically significant difference in terms of 5 parameters. The maxillary intermolar width and axial inclination of the maxillary left and right first molars showed a greater increase in the quad-helix group than in the control group. Greater decrease was observed in terms of the maxillary intermolar angle in the quad helix group, whereas in the expansion plate

Table V. Evaluation of the changes in the control group (n = 10) due to growth and development in a mean of 1.2 years

	Beginning of Stage I		*End of Stage II*		*Difference*		
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{D}$	*SD*	*Wilcoxon test*
Orthodontic cast measurements							
1. Maxillary intermolar width	44.2	1.9	44.9	2.1	0.7	0.5	**
2. Maxillary intercanine width (n = 6)	30.0	2.1	31.6	2.8	1.6	0.9	*
3. Mandibular intermolar width	42.3	1.9	42.5	1.9	0.2	0.3	
4. Mandibular intercanine width (n = 9)	25.9	1.1	26.3	1.0	0.4	0.4	*
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	85.7	4.6	88.1	4.8	2.4	3.1	*
6. ⌊6 Axial inclination	85.3	7.7	85.4	7.5	0.1	4.8	
7. Maxillary intermolar angle	9.1	8.8	6.6	7.8	–2.5	4.2	
8. Maxillary apical base width	58.4	3.2	58.8	3.0	0.4	0.3	*
9. Nasal width	26.1	2.2	26.8	2.4	0.7	0.4	*
Lateral cephalometric measurements							
10. SNA	80.2	4.2	80.2	4.0	0.0	0.6	
11. SNB	75.6	4.2	75.5	4.3	–0.1	0.6	
12. ANB	4.6	2.5	4.7	2.2	0.1	0.7	
13. SN/GoGn	36.9	5.5	37.1	5.6	0.2	1.1	
14. Maxillary incisor/SN	100.3	7.3	100.4	6.8	0.1	1.3	
15. Maxillary incisor height	25.3	1.7	25.7	1.8	0.4	0.8	
16. Maxillary molar height	18.9	1.4	19.4	1.4	0.5	0.6	*
17. Age	9.4	1.3	10.6	1.3	1.2	0.2	

*$P < .05$.
**$P < .01$.

Table VI. Evaluation of the changes in the expansion plate group (n = 13) in a mean of 1.2 years

	Pretreatment		*Posttreatment*		*Difference*		
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{D}$	*SD*	*Wilcoxon test*
Orthodontic cast measurements							
1. Maxillary intermolar width	42.9	1.5	46.8	2.3	3.9	2.1	**
2. Maxillary intercanine width (n = 10)	30.3	1.8	33.2	2.3	2.9	1.1	**
3. Mandibular intermolar width	42.5	1.6	42.8	2.1	0.3	1.0	
4. Mandibular intercanine width (n = 12)	25.3	1.7	26.2	1.8	0.9	0.9	*
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	79.7	8.5	83.1	9.6	3.4	5.2	*
6. ⌊6 Axial inclination	80.6	6.6	85.1	8.7	4.5	6.2	*
7. Maxillary intermolar angle	19.7	13.9	11.8	16.3	–7.9	10.0	*
8. Maxillary apical base width	58.1	2.3	59.2	2.6	1.1	1.4	*
9. Nasal width	25.5	3.1	26.0	3.2	0.5	0.4	**
Lateral cephalometric measurements							
10. SNA	79.1	3.9	79.1	3.4	0.0	1.1	
11. SNB	75.7	3.0	76.1	2.9	0.4	1.0	
12. ANB	3.3	2.2	2.9	2.1	–0.4	1.0	
13. SN/GoGn	36.6	4.3	36.7	4.1	0.1	0.7	
14. Maxillary incisor/SN	100.3	3.8	102.1	4.7	1.8	3.4	
15. Maxillary incisor height	25.9	2.1	26.9	2.5	1.0	1.2	*
16. Maxillary molar height	19.5	2.1	20.2	1.6	0.7	1.0	*
17. Age	9.3	1.1	10.5	1.3	1.2	0.3	

*$P < .05$.
**$P < .01$.

Table VII. Evaluation of the changes in the quad-helix group (n = 14) in a mean of 0.6 year

	Pretreatment		Posttreatment		Difference		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{D}$	SD	Wilcoxon test
Orthodontic cast measurements							
1. Maxillary intermolar width	41.4	2.6	47.0	3.1	5.6	1.9	**
2. Maxillary intercanine width (n = 9)	29.5	2.3	32.6	1.9	3.1	1.9	**
3. Mandibular intermolar width	41.6	2.4	41.9	2.4	0.3	1.1	
4. Mandibular intercanine width (n = 11)	26.1	1.5	26.2	1.4	0.1	0.6	
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	79.6	10.0	89.3	10.4	9.7	4.4	**
6. ⌊6 Axial inclination	80.9	9.3	90.4	8.3	9.5	5.5	**
7. Maxillary intermolar angle	19.4	17.9	0.9	16.8	–18.5	6.3	**
8. Maxillary apical base width	56.5	2.8	57.9	3.1	1.4	1.2	**
9. Nasal width	24.7	3.0	25.3	3.2	0.6	0.4	**
Lateral cephalometric measurements							
10. SNA	78.3	2.3	78.5	2.3	0.2	0.7	
11. SNB	75.7	2.7	75.8	2.8	0.1	1.3	
12. ANB	2.6	2.7	2.8	2.9	0.2	1.2	
13. SN/GoGn	38.3	3.7	38.3	3.9	0.0	1.6	
14. Maxillary incisor/SN	101.9	4.8	102.7	4.9	0.8	1.9	
15. Maxillary incisor height	26.0	3.3	26.4	3.3	0.4	0.5	*
16. Maxillary molar height	20.5	2.0	20.8	2.2	0.3	1.0	
17. Age	9.7	1.4	10.3	1.4	0.6	0.2	

*P < .05.
**P < .01.

Table VIII. Evaluation of actual changes from expansion plate treatment by comparing the changes in the expansion plate group in a mean of 0.6 year with the changes in the control group in a mean of 0.7 year

	Expansion plate group (n = 13)			Control group (n = 10)			Mann–Whitney U test
	$\bar{D}$	Wilcoxon test	S	$\bar{D}$	Wilcoxon test	S	
Orthodontic cast measurements							
1. Maxillary intermolar width	1.8	**	1.0	0.4	*	0.3	††
2. Maxillary intercanine width							
Control (n = 7)	1.5	**	0.8	0.7	*	0.5	†
Expansion plate (n = 9)							
3. Mandibular intermolar width	0.1		0.5	0.1		0.2	
4. Mandibular intercanine width							
Control (n = 8)	0.4	*	0.4	0.2	*	0.2	
Expansion plate (n = 1)							
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	1.7	*	2.5	1.3		2.0	
6. ⌊6 Axial inclination	2.3	*	2.9	0.2		2.8	
7. Maxillary intermolar width	–4.0	*	4.9	–1.5		3.4	
8. Maxillary apical base width	0.5	*	0.6	0.1		0.2	†
9. Nasal width	0.2	**	0.2	0.4		0.3	
Lateral cephalometric measurements							
10. SNA	0.1		0.6	0.0		0.4	
11. SNB	0.2		0.4	–0.2		0.4	†
12. ANB	0.1		0.6	0.1		0.6	
13. SN/GoGn	0.1		0.3	0.2		0.8	
14. Maxillary incisor/SN	0.8		1.5	–0.1		0.7	
15. Maxillary incisor height	0.4	*	0.5	0.1		0.6	
16. Maxillary molar height	0.3	*	0.5	0.5		0.7	
17. Duration	0.6		0.0	0.7		0.2	

The changes in the expansion plate group have been calculated by devaluating to 0.6 year.
Wilcoxon test: *P < .05; **P < .01.
Mann-Whitney test:†P < .05; ††P < .01.

Table IX. Evaluation of actual changes due to expansion plate treatment by comparing the changes in the expansion plate group in a mean of 1.2 years with the changes in the control group in a mean of 1.2 years

	Expansion plate group (n = 13)			*Control group (n = 10)*			*Mann–Whitney U test*
	$\bar{D}$	*Wilcoxon test*	*S*	$\bar{D}$	*Wilcoxon test*	*S*	
Orthodontic cast measurements							
1. Maxillary intermolar width	3.9	**	2.1	0.7	**	0.5	††
2. Maxillary intercanine width							
Control (n = 6)	2.9	**	1.1	1.6	*	0.9	†
Expansion plate (n = 10)							
3. Mandibular intermolar width	0.3		1.0	0.2		0.3	
4. Mandibular intercanine width							
Control (n = 9)	0.9	*	0.9	0.4	*	0.4	
Expansion plate (n = 12)							
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	3.4	*	5.2	2.4	*	3.1	
6. ⌊6 Axial inclination	4.5	*	6.2	0.1		4.8	
7. Maxillary intermolar width	–7.9	*	10.0	–2.5		4.2	
8. Maxillary apical base width	1.1	*	1.4	0.4		0.3	
9. Nasal width	0.5	**	0.4	0.7	*	0.4	
Lateral cephalometric measurements							
10. SNA	0.0		1.1	0.0		0.6	
11. SNB	0.4		1.0	–0.1		0.6	
12. ANB	–0.4		1.0	0.1		0.7	
13. SN/GoGn	0.1		0.7	0.2		1.1	
14. Maxillary incisor/SN	1.8		3.4	0.1		1.3	
15. Maxillary incisor height	1.0	*	1.2	0.4		0.8	
16. Maxillary molar height	0.7	*	1.0	0.5	*	0.6	
17. Duration	1.2		0.3	1.2		0.2	

Wilcoxon test: *$P < .05$; **$P < .01$.
Mann-Whitney test:†$P < .05$; ††$P < .01$.

group the mandibular intercanine width showed a greater increase.

DISCUSSION

In this study, it was observed that the maxillary intermolar and maxillary intercanine widths were increased as a result of both expansion plates and quad-helix appliances. Various researchers who have investigated the influence of expansion plates in the treatment of posterior crossbite and reported that the maxillary intermolar width[12,14,25,26] and the maxillary intercanine width[14,27] increased as a result of this appliance. However, the researchers mentioned here did not have a control group in their studies. Whereas Frank and Engel,[28] who investigated the effects of the quad-helix appliance, declared that statistically significant increases due to the appliance were observed in the maxillary intermolar and maxillary intercanine widths measured on frontal cephalometric radiographs instead of orthodontic models; this investigation used a control group consisting of normal individuals. Tables XI and XII show that the maxillary intermolar width increased to a larger extent because of the quad-helix appliance. This difference between the two treatment groups is a consequence of the fact that the maxillary intermolar width was less in the quad-helix than in the expansion plate group at the start of the treatment. Boysen et al[14] and Herold,[27] who compared the influences of the quad-helix appliances and expansion plates, were not able to find a difference between the two treatment methods with regard to the increase in the maxillary intermolar width.

As seen in Table XII, a significant increase was observed in the mandibular intercanine width in the expansion plate group during an average period of 1.2 years. In the quad-helix group, a statistically insignificant increase occurred in 0.6 year. The comparison of the changes that occurred in the expansion plate and quad-helix appliance groups showed a statistically significant difference. Yet an increase of 0.9 mm in the expansion plate group is not actually a treatment change due to the expansion plate treatment because no difference was found in the mandibular intercanine width when the increases in the expansion plate group and control group were compared (Table XII). The reason why there was no significant difference between the expansion plate and quad-helix group with respect to the increase in mandibular intercanine width is that

Table X. Evaluation of actual changes due to quad-helix treatment by comparing the changes in the quad-helix group in a mean of 0.6 year with the changes in the control group in a mean of 0.7 year

	Quad-helix group (n = 14)			*Control group (n = 10)*			*Mann–Whitney U test*
	$\bar{D}$	*Wilcoxon test*	*S*	$\bar{D}$	*Wilcoxon test*	*S*	
Orthodontic cast measurements							
1. Maxillary intermolar width	5.6	**	1.9	0.4	*	0.3	†††
2. Maxillary intercanine width							
Quad-helix (n = 9)	3.1	**	1.9	0.7	*	0.5	††
Control (n = 7)							
3. Mandibular intermolar width	0.3		1.1	0.1		0.2	
4. Mandibular intercanine width							
Quad-helix (n = 11)	0.1		0.6	0.2	*	0.2	
Control (n = 8)							
Frontal cephalometric measurements							
5. 6⌋ Axial inclination	9.7	**	4.4	1.3		2.0	†††
6. ⌊6 Axial inclination	9.5	**	5.5	0.2		2.8	†††
7. Maxillary intermolar width	–18.5	**	6.3	–1.5		3.4	†††
8. Maxillary apical base width	1.4	**	1.2	0.1		0.2	††
9. Nasal width	0.6	**	0.4	0.4		0.3	
Lateral cephalometric measurements							
10. SNA	0.2		0.7	0.0		0.4	
11. SNB	0.1		1.3	–0.2		0.4	
12. ANB	0.2		1.2	0.1		0.6	
13. SN/GoGn	0.0		1.6	0.2		0.8	
14. Maxillary incisor/SN	0.8		1.9	–0.1		0.7	
15. Maxillary incisor height	0.4	*	0.5	0.1		0.6	
16. Maxillary molar height	0.3		1.0	0.5		0.7	
17. Duration	0.6		0.2	0.7		0.2	

Wilcoxon test: *$P < .05$; **$P < .01$.
Mann-Whitney test:†$P < .05$; ††$P < .01$; †††$P < .001$.

the average period of treatment was 1.2 years in the expansion plate group and 0.6 year in the quad-helix group. If the expansion plate had an effect on the increase in mandibular intercanine width, a significant difference would be expected when the changes in the two treatment groups in an average period of 0.6 year were compared (Table XI). If the quad-helix group had been observed for 1.2 years, it would have been quite unlikely for a significant difference between the groups to be found.

In the expansion plate group, significant increases were observed in the inclination of the maxillary left and right first permanent molars both in 0.6 year and 1.2 years (Tables XI and XII). However, these are not actual changes because of the treatment because no significant differences in these parameters were found between the groups in the expansion plate group and the control group. On the other hand, in the quad-helix group significant increases were measured in the inclination of the maxillary left and right first permanent molars in a span of 0.6 year (Table XII). The comparison of the changes that occurred in the two groups exhibited a significant difference. This result shows that the inclination of the maxillary first permanent molars increased not because of expansion plate treatment but, to a greater extent, because of quad-helix treatment. In other words, buccal tipping was observed.

Tables XI and XII demonstrate a significant decrease in the maxillary intermolar angle in the expansion plate group, both in 0.6 year and 1.2 years. However, comparing the expansion plate group with the control group demonstrates that this decrease in the value is not statistically significant or, in other words, was not due to expansion plate treatment. In the quad-helix group, a significant decrease due to treatment was observed in this angle within a span of 0.6 year (Table XII). The comparison of the change that occurred in the two groups exhibited a significant difference. This result proves that the maxillary intermolar angle decreased because of the quad-helix treatment. The buccal tipping in the maxillary first permanent molars under the influence of the quad-helix appliance resulted in a decrease in the maxillary intermolar angle. Boysen et al,[14] who compared the effect of the quad-helix appliance and expansion plates, reported that the quad-helix appliance changed the inclination of the maxillary first permanent molars only slightly, whereas a considerable tipping in the teeth was

Table XI. Evaluation of the difference between the two treatment methods by comparing the changes in the quad-helix and expansion plate group with a mean 0.6 year

	Expansion plate group (n = 13)				*Quad-helix group (n = 14)*				
	Expansion plate			*Expansion plate & control*	*Quad-helix*			*Quad-helix & control*	*Expansion plate & Quad helix*
	$\bar{D}$	*Wilcoxon test*	*S*	*U test*	$\bar{D}$	*Wilcoxon test*	*S*	*U test*	*U test*
Orthodontic cast measurements									
1. Maxillary intermolar width	1.8	**	1.0	††	5.6	**	1.9	†††	†††
2. Maxillary intercanine width									
Quad-helix (n = 9)	1.5	**	0.8	†	3.1	**	1.9	††	
Expansion plate (n = 10)									
3. Mandibular intermolar width	0.1		0.5		0.3		1.1		
4. Mandibular intercanine width									
Quad-helix (n = 11)	0.4	*	0.4		0.1		0.6		
Expansion plate (n = 12)									
Frontal cephalometric measurements									
5. 6⌋ Axial inclination	1.7	*	2.5		9.7	**	4.4	†††	†††
6. ⌊6 Axial inclination	2.3	*	2.9		9.5	**	5.5	†††	†††
7. Maxillary intermolar angle	–4.0	*	4.9		–18.5	**	6.3	†††	†††
8. Maxillary apical base width	0.5	*	0.6	†	1.4	**	1.2	††	†
9. Nasal width	0.2	**	0.2		0.6	**	0.4		
Lateral cephalometric measurements									
10. SNA	0.1		0.6		0.2		0.7		
11. SNB	0.2		0.4	†	0.1		1.3		
12. ANB	–0.1		0.6		0.2		1.2		
13. SN/GoGn	0.1		0.3		0.0		1.6		
14. Maxillary incisor/SN	0.8		1.5		0.8		1.9		
15. Maxillary incisor height	0.4	*	0.5		0.4	*	0.5		
16. Maxillary molar height	0.3	*	0.5		0.3		1.0		
17. Duration	0.6		0.0		0.6		0.2		

The changes in the expansion plate group have been calculated by devaluating to 0.6 year.
Wilcoxon test: *P < .05; **P < .01.
Mann-Whitney test:†P < .05; ††P < .01; †††P < .001.

observed because of the expansion plate. The quad-helix appliance used by Boysen et al[14] was made of 0.9 mm blue Elgiloy wire and soldered to molar bands. Urbaniak et al,[29] who conducted an in vitro investigation on the effect of the wire type and diameter on the force exerted by the quad-helix appliance, showed that the force exerted by the appliance would decrease as the diameter of wire decreased. The investigators did not find any difference between the blue Elgiloy and stainless steel wire appliances in terms of the amount of force exerted. As was mentioned above, Boysen et al[14] used a 0.9 mm blue Elgiloy quad-helix appliance, whereas the one used in the present investigation was made of a 0.9 mm stainless steel wire. Given that the two appliances are the same diameter and there is no difference in the forces exerted by two different types of wires,[29] the reason why a smaller increase with the quad-helix appliance in the inclination of the maxillary first permanent molars was found in the investigation by Boysen et al[14] than in the present investigation, may be the result of the activation of the appliance, which was done only once at the start of the treatment. This allowed time for the buccal root torque effect on the maxillary first permanent molars.

Table XI exhibits a statistically significant difference between the increases in maxillary apical base width in the expansion plate and quad-helix appliance groups within a span of 0.6 year. Table XII, on the other hand, exhibits a statistically insignificant difference between the increases in maxillary apical base width in 1.2 years in the expansion plate group and in 0.6 year in the quad-helix group. The insignificant difference between the groups (shown in Table XII) is a consequence of the fact that the average treatment period in the expansion plate group was twice the average treatment period in the quad-helix group. If the quad-helix group had been observed for 1.2 years, a significant difference between the groups would have been observed as well.

Similarly, Frank and Engel[28] reported an increase

Table XII. Evaluation of the difference between the two treatment methods by comparing the changes in the expansion plate group with a mean 1.2 years with the changes in the quad-helix group with a mean of 0.6 year

	Expansion plate group (n = 13)				*Quad-helix group (n = 14)*				
	Expansion plate			*Expansion plate & control*	*Quad-helix*			*Quad-helix & control*	*Expansion plate & Quad helix*
	$\bar{D}$	*Wilcoxon test*	*S*	*U test*	$\bar{D}$	*Wilcoxon test*	*S*	*U test*	*U test*
Orthodontic cast measurements									
1. Maxillary intermolar width	3.9	**	2.1	††	5.6	**	1.9	†††	†
2. Maxillary intercanine width									
Quad-helix (n = 9)	2.9	**	1.1	†	3.1	**	1.9	††	
Expansion plate (n = 10)									
3. Mandibular intermolar width	0.3		1.0		0.3		1.1		
4. Mandibular intercanine width									
Quad-helix (n = 11)	0.9	*	0.9		0.1		0.6		†
Expansion plate (n = 12)									
Frontal cephalometric measurements									
5. 6⌋ Axial inclination	3.4	*	5.2		9.7	**	4.4	†††	††
6. ⌊6 Axial inclination	4.5	*	6.2		9.5	**	5.5	†††	†
7. Maxillary intermolar angle	–7.9	*	10.0		–18.5	**	6.3	†††	††
8. Maxillary apical base width	1.1	*	1.4		1.4	**	1.2	††	
9. Nasal width	0.5	**	0.4		0.6	**	0.4		
Lateral cephalometric measurements									
10. SNA	0.0		1.1		0.2		0.7		
11. SNB	0.4		1.0		0.1		1.3		
12. ANB	–0.4		1.0		0.2		1.2		
13. SN/GoGn	0.1		0.7		0.0		1.6		
14. Maxillary incisor/SN	1.8		3.4		0.8		1.9		
15. Maxillary incisor height	1.0	*	1.2		0.4	*	0.5		
16. Maxillary molar height	0.7	*	1.0		0.3		1.0		
17. Duration	1.2		0.3		0.6		0.2		

Wilcoxon test: $*P < .05$; $**P < .01$.
Mann-Whitney test: $\dagger P < .05$; $\dagger\dagger P < .01$; $\dagger\dagger\dagger P < .001$.

in maxillary apical base width because of the quad-helix appliance. Bell and Lecompte,[30] on the other hand, observed that sutura palatina media opened on the occlusal radiographs taken at the end of the treatment of individuals with posterior crossbite treated with quad-helix appliance. The issue of the extent in which horizontal growth of the maxilla may be because of the growth in sutura palatina media and to what extent it may be because of the bone apposition on the external surfaces is widely disputed. Scott[31] claims that sutura palatina media is an active point of growth in the prenatal period but that it is not known exactly whether there is growth in this sutura after birth. Latham[32] reported that no histologic evidence shows that there is active growth in sutura palatina media after the ages of 2 or 3. However, Björk and Skieller[33] have proven by their implant studies that the growth in sutura palatina media was the most important factor in the horizontal growth of the maxilla. In addition, Melsen[34] showed in her histologic study that the growth in sutura palatina media continued until the postpubertal period. Because no occlusal radiographs were taken in our investigation, it would not be appropriate to say that the increase in the maxillary apical base width observed in the quad-helix treatment is a consequence of the opening in sutura palatina media. Still, the increase in the maxillary apical base width can be thought to be related to a stimulus of the sutura palatina media.

CONCLUSION

In this investigation, dentally maxillary intermolar width and intercanine width have been found to increase as a result of treatment with expansion plate after a period of approximately 1.2 years. Dentally maxillary intermolar and intercanine widths and axial inclinations of maxillary first molars have increased while the intermolar angle decreased with quad-helix appliance. Skeletally maxillary apical base width has increased with the quad-helix appliance after a treatment period of 0.6 year.

It was observed that transverse expansion was achieved by both the expansion plate and the quad-helix appliance. However, the period of treatment was 1.2 years for the expansion plate and 0.6 year for the quad-helix appliance. Although posterior crossbite was corrected by the quad-helix appliance in a fairly short period of time, the appliance caused considerable buccal tipping in the maxillary first permanent molars. If the quad-helix appliance, with its lock and key mechanism, is to be preferred for its shorter period of treatment and its greatest advantage of not requiring patient cooperation, we consider it more appropriate to reduce the activation degree of the appliance. This should be done in order to prevent undesirable buccal tipping in the maxillary first permanent molars and to activate the retention loops of the quad-helix appliance, which are soldered to the palatinals of the maxillary first permanent molar bands, in such a way as to allow for buccal root torque movement in the molars.

REFERENCES

1. Kutin G, Hawes RR. Posterior crossbites in the deciduous and mixed dentitions. Am J Orthod 1969;56:491-504.
2. Hanson MI, Barnard LW, Case JL. Tongue thrust preschool children. Part II: dental occlusal patterns. Am J Orthod 1970;57:15-22.
3. Clifford FO. Cross-bite correction in the deciduous dentition: principles and procedures. Am J Orthod 1971;59:343-9.
4. Day AJW, Foster TD. An investigation into the prevalence of molar crossbite and some associated aetiological conditions. Dent Prac 1971;21:402-10.
5. King DL. Functional posterior crossbite in the deciduous and early mixed dentition Gen Dent 1978;January-February:36-40.
6. Kurol J, Berglund L. Longitudinal study and cost-benefit analysis of the effect of early treatment of posterior crossbites in the primary dentition. Eur J Orthod 1992;14:173-9.
7. Lim ST, Chen ML. Management of the posterior dental or functional crossbite in the primary or mixed dentition. Singapore Dent J 1977;3:11-4.
8. Purcell PD. Effectiveness of posterior crossbite correction during the mixed dentition. J Pedod 1985;9:302-10.
9. Schröder U, Schröder I. Early treatment of unilateral posterior crossbite in children with bilaterally contracted maxilla. Eur J Orthod 1984;6:65-9.
10. Thilander B, Wahlund S, Lennartsson B. The effect of early interceptive treatment in children with posterior cross-bite. Eur J Orthod 1984;6:25-34.
11. Buck DL. The fixed W arch for correction of posterior crossbites in children. J Am Dent Assoc 1970;81:1140-2.
12. Ranta R. Treatment of unilateral posterior crossbite: comparison of the quad-helix and removable plate. J Dent Child 1988;55:102-4.
13. Thilander B, Ronning O. Introduction to orthodontics. Stockholm Tandlakarförlaget 1985;110:139.
14. Boysen B, LaCour K, Athanasiou AT, Gjessing PE. Three-dimensional evaluation of dentoskelatal changes after posterior crossbite correction by quad-helix or removable appliances. Br J Orthod 1992;19:97-107.
15. Asher C. The removable quad-helix appliance. Br J Orthod 1985;12:40-5.
16. Birnie DJ, McNamara TG. The quad-helix appliance. Br J Orthod 1980;7:115-20.
17. Filho Silva OG, Neto JA, Almeida RR. Early correction of posterior crossbite: biomechanical characteristics of the appliances. J Pedod 1989;13:195-221.
18. Jones SP. Waters NE. The quad-helix maxillary expansion appliance: part I mechanics. Eur J Orthod 1989;11:169-78.
19. Chaconas SJ, Alba Levy JA. Orthopedic and orthodontic applications of the quad helix appliance. Am J Orthod 1977;72:422-8.
20. Uzel I, Enacar A. Ortodontide Sefalometri. Ankara: Yargiçoglu Matbaasi, 1984.
21. Perkün F. Çene Ortopedisi (Ortodonti).Cilt 1 Istanbul: Gençlik Basimevi; 1977. p. 32-44.
22. Salzman JA. Practice of orthodontics, volume one. Philadelphia: JB Lippincott; 1966. p. 480-517.
23. Salzman JA. Orthodontics in practice. Philadelphia: JB Lippincott; 1974. p. 183-92.
24. Dahlberg G. Statistical methods for medical and biological students. In: Seipei CM, editor. variation of tooth position. Lund Hakan Ohlssons Boktryckeri 1946;25:8.
25. Hermanson H, Kurol J, Rönnerman A. Treatment of unilateral posterior crossbite with quad-helix and removable plates: a retrospective study. Eur J Orthod 1985;7:97-102.
26. Skieller V. Expansion of the midpalatal suture by removable plates: analyzed by the implant method. Trans Eur Orthod Soc 1964;143-57.
27. Herold JS. Maxillary expansion: a retrospective study of three methods of expansion and their long-term sequelae. Br J Orthod 1989;16:195-200.
28. Frank SW, Engel GA. The effects of maxillary quad-helix appliance expansion on cephalometric measurements in growing orthodontic patients. Am J Orthod 1982;81:378-89.
29. Urbaniak JA, Brantley WA, Pruhs RJ, Zussman RL, Post AC. Effect of appliance size, arch wire diameter, and alloy composition on the in vitro force delivery of the quad-helix appliance. Am J Orthod Dentofacial Orthop 1988;94:311-6.
30. Bell RA, Lecompte EJ. The effects of maxillary expansion using a quad-helix appliance during the deciduous and mixed dentitions. Am J Orthod 1981;79:152-61.
31. Scott JH. Dentofacial development and growth. London: Pergamon Press; 1967. p. 114.
32. Latham RA. The development, structure, and growth pattern of the human midpalatal suture. J Anatomy 1971;108:31-41.
33. Björk A, Skieller V. Growth of the maxilla in three dimensions as revealed radiographically by the implant method. Br J Orthod 1977;4:53-64.
34. Melsen B. Palatal growth studied on human autopsy material: a histological microradiographical study. Am J Orthod 1975;68:42-54.