Original Article

The Effects of Nitanium Maxillary Expander Appliances on Dentofacial Structures

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Abstract: The aim of this study was to determine the sagittal, transverse, and vertical effects of a Nitanium maxillary expansion appliance on dentofacial structures in patients with bilateral posterior cross bites in the permanent dentition. For this purpose, and without distinguishing the skeletal classification, a total of 16 patients (4 boys and 12 girls) with a mean age of 13.8 years and a bilateral posterior cross-bite in the permanent dentition were chosen. Lateral and frontal cephalometric radiographs, maxillary and mandibular plaster models and periapical radiographs were obtained from each patient at pretreatment (T1), post-treatment (T2), and at the end of the retention period (T3) time points. The measurements that were obtained from the lateral and frontal cephalometric radiographs and maxillary and mandibuler plaster models were evaluated by a Wilcoxon paired 2-sample test. This test compares 3 pairs of time points, the pretreatment (T1) and posttreatment (T2), the pretreatment (T1) and post retention (T3), and the post-treatment (T2) and postretention (T3). Periapical radiographs were used to demonstrate changes in the midpalatal suture. Skeletal expansion occurred simultaneously with dentoalveoller expansion in the transverse plane with the Nitanium maxillary expansion appliance. The upper incisors were extruded and retroclined. Also, the extrusion of the upper first molars caused the mandible to rotate backward and downward. This resulted in an increased vertical dimension of the lower face. It was clinically observed that the posterior cross-bite and mesiopalatal rotation of the upper first molars were improved and that the crowns of these teeth were moved slightly to the distal side. (*Angle Orthod* 2002;72:344–354.)

Key Words: Nitanium maxillary expansion appliance

INTRODUCTION

An estimated 25% to 30% of all orthodontic patients can benefit from maxillary expansion and 85% of the Class II cases can be improved by molar rotation, distalization, and expansion.[1] The correction of a posterior cross bite in young patients is often accomplished by a combination of skeletal and dental expansion. Skeletal expansion involves separating the maxillary halves at the midpalatal suture and dental expansion results from buccal tipping of the maxillary posterior teeth.[2–5] The proportion of skeletal and dental movement is dependent on the rate of expansion, the age of the patient, the amount of force applied, and the appliance type.[3,4,6] The goal of maxillary expansion is to maximize skeletal movement and minimize dental movement, while allowing for physiologic adjustment of the suture during separation.[3,7]

Expansion appliances can be classified as rapid or slow. Rapid Maxilary Expansion (RME) appliances have been shown to produce force ranging from 3 to more than 20 pounds.[8] Studies have documented free-floating bone fragments, bleeding, microfractures, cyst formation, vascular disorganization, and connective tissue inflammation in suture sites during rapid expansion.[5] Also, these appliances will not rotate or distalize molars.[9–11]

Story[3] and Ekstrom[12] have suggested that slow expansion procedures allow physiologic adjustments and reconstitution of the sutural elements over a period of about 30 days. McAndrew[13] demonstrated that the application of light, continuous forces in areas of periosteal growth allows normal arch dimensions to develop at any age without undue tipping of the abutment teeth. Increased fibroblastic, osteoclastic, and osteoblastic activities seem to occur when the maxilla is widened slowly. Slower expansion has also been associated with more physiologic stability and less potential for relapse than rapid expansion. The neuromuscular adaptation of the mandible to the maxilla in slow expansion allows a normal vertical closure.[14]

In 1993, Arndt[9] developed a fixed-removable tandem-

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TABLE 1. Distribution of Patients, Mean Ages, Mean Expansion, and Retention Periods

	n	Mean Age	Expansion Period	Retention Period
Boys	4	14.1 years	3.6 months	3.1 months
Girls	12	13.7 years	3.5 months	3.0 months
Total	16	13.9 years	3.5 months	2.9 months

loop nickel-titanium maxillary expander (NiTi, Nitanium). A Nitanium maxillary expander (NME) is capable of a uniform, slow, continuous force for maxillary expansion, molar rotation, molar distalization, and arch development. This appliance expands at a rate that maintains tissue integrity during repositioning and remodeling of the teeth and bone. In other words, as the palate expands, regeneration matches the rate of expansion.

The action of the NME is made possible by harnessing nitanium's properties of shape memory and transition temperature. Shape memory is the ability to constantly return to a set shape after deformation. Nickel and titanium form an alloy with a specific thermal transition temperature (in the case of the NME, 84°F). At temperatures higher than the transition temperature, interatomic forces bind the atoms more tightly, producing a stiffer metal. At lower temperatures, the forces weaken, making the metal more flexible.[9,10]

The NME delivers a force of 350 g in 3 mm increments. If a 4 mm expansion appliance is placed, the force will initially be higher, but will return to 350 g once 3 mm of expansion has occurred. Because the force application is preprogrammed, it is self-limiting. Nevertheless, slight adjustments can be made by the clinician at any time to constrict the appliance or add further expansion. The expanders come in eight different intermolar widths ranging from 26 mm to 47 mm. A size that is 3 mm wider than the transverse distance between the maxillary first molar should be selected.[9] The aim of this study was to evaluate the effects of NME on dentofacial structures.

MATERIALS AND METHODS

The study included 16 patients treated with NME at the Selçuk University Department of Orthodontics. The criteria for patient selection included patients in the permanent dentition who required maxillary expansion as part of their comprehensive orthodontic treatment. The NME group was comprised of four boys and 12 girls with an average age of 13.8 years. All patients had a bilateral cross bite at the start of treatment. The average treatment and retention periods were 3.6 months and 2.8 months, respectively (Table 1).

The NME[1] (GAC International, Central Islip, NY) is a tandem-loop, temperature-activated expansion appliance previously described by Arndt.[9] The appliance consists of two tandem, temperature-sensitive, 0.035-in diameter NiTi transpalatal loops that are connected bilaterally to the lin-

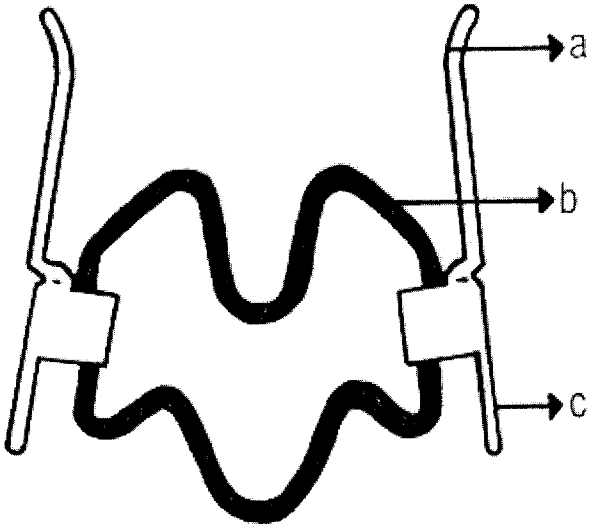

FIGURE 1. NPE expander. (a) 0.032 inch stainless steel wire; (b) 0.035 inch thermal activated Nitanium; (c) stainless steel attachment for lingual tube.

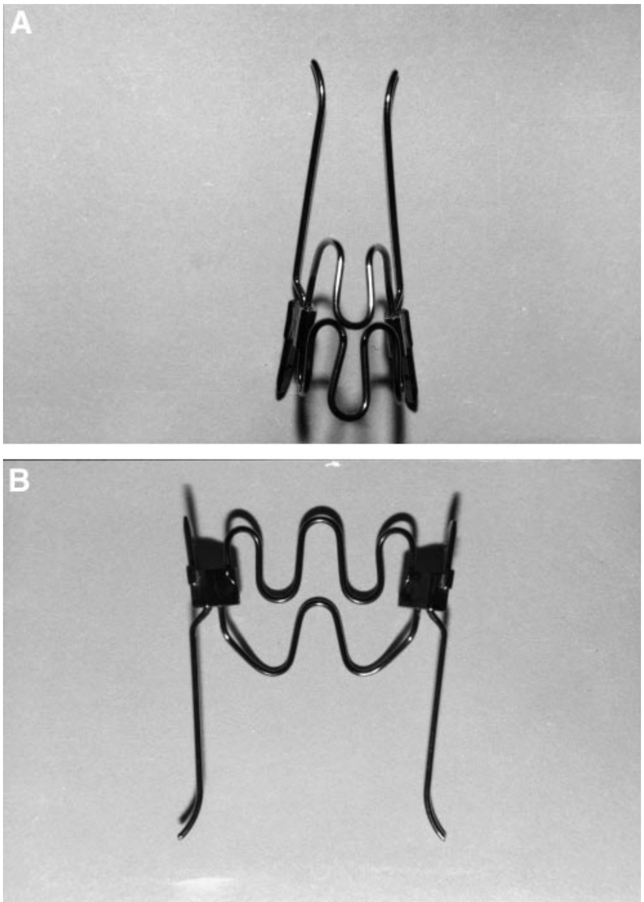

FIGURE 2. (a) Degree of compression when prototype appliance was chilled to 20° below transition temperature. (b) Effect of shape memory when appliance was warmed to body temperature.

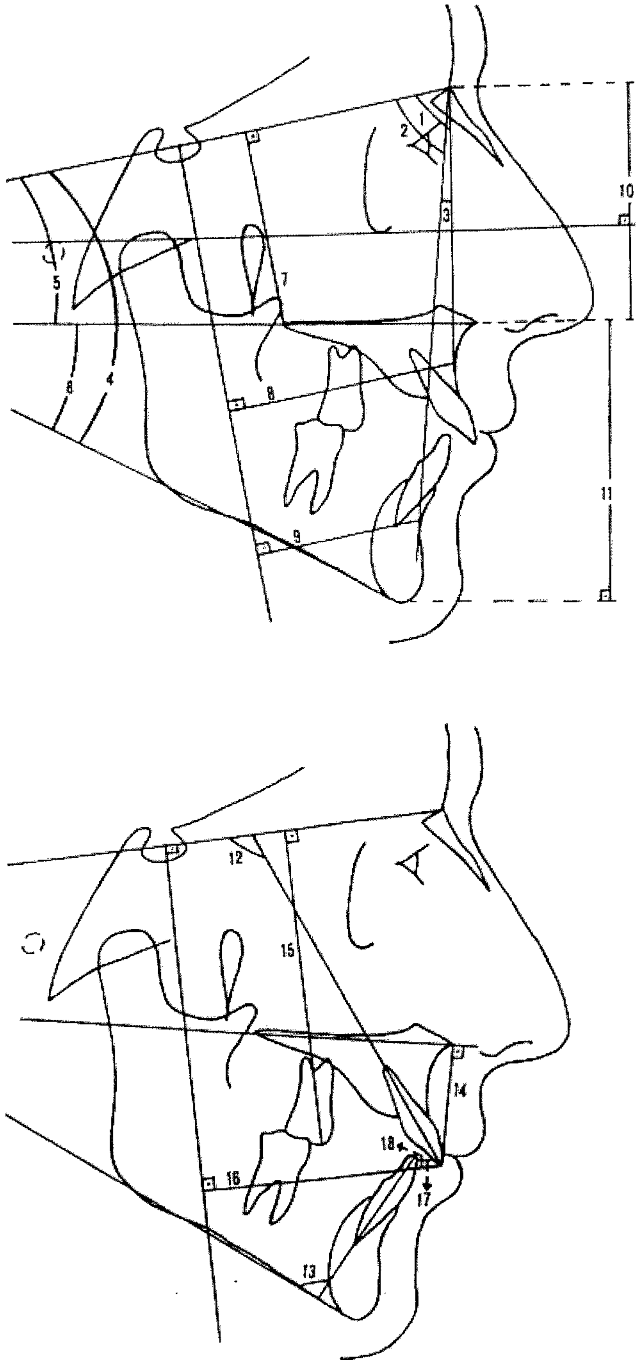

FIGURE 3. Lateral cephalometric measurements: (1) SNA, (2) SNB, (3) ANB, (4) SN-MP, (5) SN-PP, (6) MP-PP, (7) SN⊥PNS, (8) SV⊥A, (9) SV⊥B, (10) N-ANS, (11) ANS-Me, (12) U1P-SN, (13) L1P-MP, (14) PP⊥U1, (15) SN⊥U6, (16) SV⊥U1, (17) overjet, and (18) overbite.

gual sheaths of the maxillary molar bands. Anteriorly, a 0.032-inch diameter stainless steel wire forms a finger-spring designed for lateral expansion in the canine and premolar region (Figure 1).

The appliance is manufactured in eight sizes in 3-mm increments. To select the proper size, measure from the intermolar lingual groove at the gingiva to the opposite lingual groove and add 3 to 4 mm. For placement of the appliance, NiTi transpalatal loops are cooled with freeze-gel packs (Figure 2).

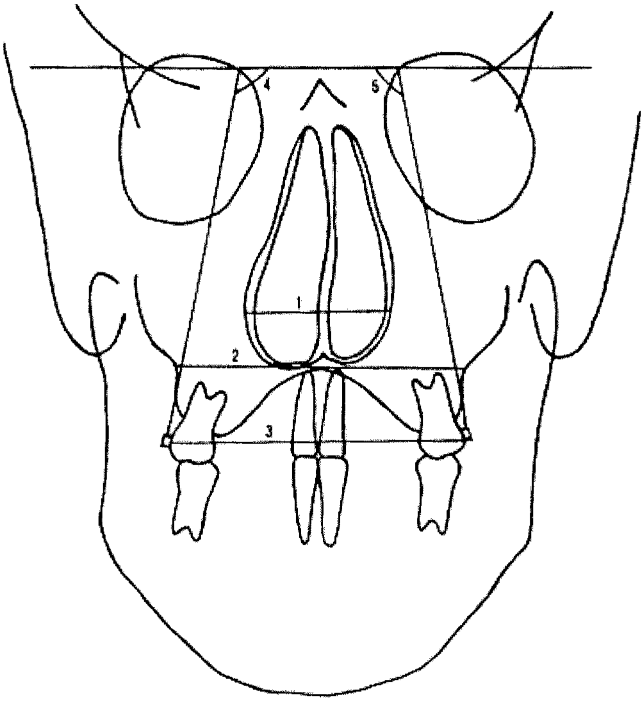

FIGURE 4. Frontal cephalometric measurements: (1) nasal cavity width (NC-CN), (2) maxillary width (JL-JR), (3) intermolar width (6A-A6), (4) ML angle, and (5) MR angle (ML and MR angles were determined by reference lines drawn through the images of the threaded wires intersecting cranial reference line).

The martensitic transformation and superelastic properties of the NiTi loops assist in the insertion of the expander into the lingual sheaths of refit bands, which are then cemented to both maxillary first molars. Expansion was considered adequate once the occlusal aspect of the maxillary lingual cusp of the permanent first molar contacted the occlusal aspect of the mandibular facial cusp of the permanent first molar. The appliance was removed at the end of treatment. At that time, a passive transpalatal arch with extensions in the canine and premolar region was applied for the retention period. Stainless steel rectangular wires (0.018 inch × 0.025 inch) were placed in the left and right molar tubes to evaluate the amount of molar tipping. A 5 mm vertical extension was bent on the rectangular wire that was inserted into the molar tube.

After completion of this time period, the end of retention records were taken. Fixed orthodontic appliances and a transpalatal arch were applied. Lateral and frontal cephalometric films, periapical films and upper and lower plaster models were taken pretreatment (T1), post-treatment (T2), and post-retention (T3).

The lateral and periapical cephalometric films were recorded in a Siemens Orthoceph 10 cephalometer (Hyrla, Finland). The profile radiographs were recorded with a

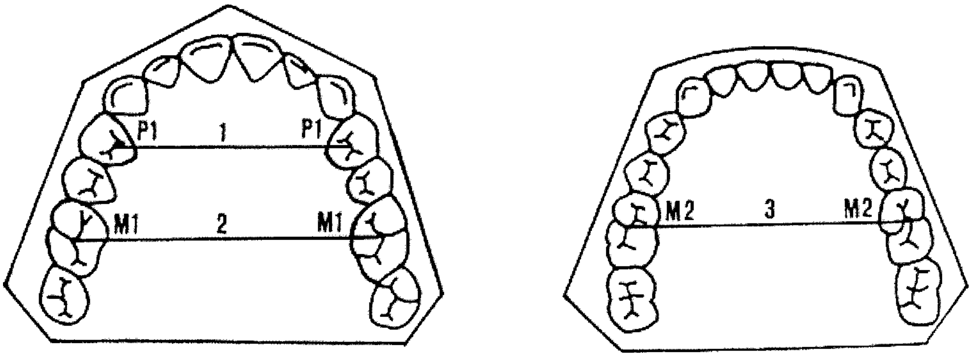

FIGURE 5. Plaster model measurements: (1) upper interpremolar width, (2) upper intermolar width, and (3) lower intermolar width.

TABLE 2. Comparison of the T1–T2 Periods†

	Measurements	T1 Period				T2 Period					
		X	SD	Min	Max	X	SD	Min	Max	*P*	Test
Lateral Cephalometric Film											
1	SNA	78.13	3.79	71.00	84.50	78.62	3.52	74.00	86.00	0.24	NS
2	SNB	76.16	3.46	72.00	84.00	74.94	3.33	70.00	83.00	0.00	**
3	ANB	1.97	2.72	−3.00	6.50	3.69	2.24	1.00	9.00	0.00	**
4	SN-MP	40.75	4.97	30.00	46.00	42.16	5.09	33.50	48.50	0.01	*
5	SN-PP	9.16	3.24	3.00	15.00	9.34	3.25	2.00	14.00	0.31	NS
6	MP-PP	31.59	4.42	24.00	37.00	32.81	4.20	26.50	38.00	0.00	***
7	NS-PNS	45.56	2.28	42.00	50.00	45.81	2.26	42.00	50.00	0.07	NS
8	SV-A	56.06	5.30	47.50	64.50	56.59	2.26	42.00	50.00	0.29	NS
9	SV-B	43.22	7.70	32.00	56.00	41.66	7.09	32.00	54.00	0.00	**
10	N-ANS	53.94	2.98	50.00	61.00	54.75	2.63	51.00	59.00	0.07	NS
11	ANS-Me	70.41	4.04	64.00	82.00	71.75	4.23	65.00	82.00	0.05	*
12	U1P-SN	100.88	5.77	91.00	109.00	98.19	5.30	90.00	107.00	0.03	*
13	L1P-MP	85.72	6.32	74.00	95.00	84.34	5.29	73.00	91.00	0.06	NS
14	PP-U1	30.31	2.56	25.00	35.00	31.09	2.20	27.50	35.00	0.02	*
15	SN-U6	72.50	3.05	68.00	79.00	73.44	3.29	69.00	81.00	0.00	**
16	SV-U1	55.19	5.26	49.00	64.50	54.75	2.63	51.00	59.00	0.02	*
17	Overjet	2.84	1.43	0.00	5.00	3.00	1.63	0.00	7.00	0.94	NS
18	Overbite	−0.16	1.69	−3.00	3.00	−0.25	2.12	−4.00	4.00	0.80	NS
Frontal Film											
1	NC-CN	32.03	2.52	28.00	37.00	32.75	2.72	29.00	39.00	0.11	NS
2	JL-JR	63.81	4.55	52.00	72.00	66.31	3.72	58.00	74.00	0.00	**
3	6A-A6	57.03	4.21	49.00	63.00	66.25	3.47	61.00	71.00	0.00	***
4	ML angle	85.75	8.36	74.00	104.00	93.94	7.60	80.00	106.00	0.00	***
5	MR angle	84.50	11.89	62.00	111.00	92.13	11.79	68.00	118.00	0.00	***
Model											
1	Upper interpremolar width	29.52	2.21	26.00	32.50	38.61	2.80	34.50	45.60	0.00	***
2	Upper intermolar width	41.48	3.66	32.80	47.00	51.43	2.96	45.00	55.60	0.008	***
3	Lower intermolar width	41.63	2.66	35.00	45.00	41.91	2.71	35.00	45.00	0.012	*

$P < .05$*, $P < .01$**, $P < .001$*** Significant *P* values are shown.
† X indicates mean; SD, standard deviation; Min, minimum; and Max, maximum.

fixed focus to midsagittal plane distance of 150 cm and a midsagittal plane to film distance of 12.5 cm. For the periapical films, the subjects were positioned with the face turned to the film. The head was positioned in the cephalostat with the Frankfort plane parallel to the floor. To standardize the magnification during the recording procedure, the ear rods were placed 15 mm away from the film. Periapical films were obtained for evidence of sutural opening. No attempt was made to evaluate the amount of midpalatal sutural opening. Evidence of sutural expansion was demonstrated by a radiolucent widening of the suture.

On the lateral cephalometric films, eight lines were used to obtain 11 skeletal and seven dental measurements. On the frontal film, five measurements were obtained. Three measurements were made on plaster models. Measurements used in the study are shown in Figures 3–5.

TABLE 3. Comparison of the T1–T3 Periods†

	Measurements	T1 Period				T3 Period					
		X	SD	Min	Max	X	SD	Min	Max	*P*	Test
Lateral Cephalometric Film											
1	SNA	78.13	3.79	71.00	84.50	77.84	3.30	73.00	85.00	0.31	NS
2	SNB	76.16	3.46	72.00	84.00	75.41	3.19	71.00	83.00	0.01	**
3	ANB	1.97	2.72	−3.00	6.50	2.44	2.07	−1.00	6.00	0.40	NS
4	SN-MP	40.75	4.97	3.00	46.00	41.78	4.52	33.00	48.00	0.01	*
5	SN-PP	9.16	3.24	3.00	15.00	9.38	2.92	5.50	14.00	0.70	NS
6	MP-PP	31.59	4.42	24.00	37.00	32.41	4.55	26.00	38.00	0.00	**
7	SN-PNS	45.56	2.28	42.00	50.00	45.75	2.11	43.00	50.00	0.31	NS
8	SV-A	56.06	5.30	47.50	64.50	55.69	4.87	48.00	63.00	0.26	NS
9	SV-B	43.22	7.70	32.00	56.00	41.94	8.00	32.00	55.00	0.02	*
10	N-ANS	53.94	2.98	50.00	61.00	54.69	2.82	50.00	61.00	0.07	NS
11	ANS-ME	70.41	4.04	64.00	82.00	71.50	5.00	91.00	106.00	0.02	*
12	U1P-SN	100.88	5.77	91.00	109.00	99.88	5.23	91.00	106.00	0.02	*
13	L1P-MP	85.72	6.32	74.00	95.00	84.94	5.96	74.00	94.00	0.09	NS
14	PP-U1	30.31	2.56	25.00	35.00	30.72	2.45	26.00	35.00	0.02	*
15	SN-U6	72.50	3.05	68.00	79.00	73.06	2.84	69.00	79.00	0.03	*
16	SV-U1	55.19	5.26	49.00	64.50	54.69	2.82	50.00	61.00	0.03	*
17	Overjet	2.84	1.43	0.00	5.00	2.69	1.46	0.00	5.00	0.50	NS
18	Overbite	−0.16	1.69	−3.00	3.00	−0.13	2.02	−4.00	4.00	0.93	NS
Frontal Film											
1	NC-CN	32.03	2.52	28.00	37.00	32.66	3.01	29.00	41.00	0.15	NS
2	JL-JR	63.81	4.55	52.00	72.00	66.06	3.92	57.00	74.00	0.00	**
3	6A-A6	57.03	4.21	49.00	63.00	65.44	3.20	60.00	70.00	0.00	***
4	ML angle	85.75	8.36	74.00	104.00	91.31	7.20	78.00	103.00	0.00	**
5	MR angle	84.50	11.89	62.00	111.00	88.31	10.77	66.00	111.00	0.01	**
Model											
1	Upper interpremolar width	29.52	2.21	26.00	32.50	38.21	2.87	33.00	45.50	0.00	***
2	Upper intermolar width	41.48	3.66	32.80	47.00	50.98	3.13	43.00	55.00	0.00	***
3	Lower intermolar width	41.63	2.66	35.00	45.00	41.81	2.69	35.00	45.00	0.08	NS

$P < .05$*, $P < .01$**, $P < .001$*** Significant *P* values are shown.
† X indicates mean; SD, standard deviation; Min, minimum; and Max, maximum.

Statistical methods

Twenty of 86 lateral and frontal films and 48 upper and lower plaster models were randomly chosen to examine for measurement error. These materials were remeasured after one month and the error of the method was calculated. The reliability of a single measurement was calculated by using Dalhberg's formula of method error. The reliability of measurements ranged between 0.25 to 0.80 in lateral cephalometric variables, 0.56 to 0.87 in frontal cephalometric variables, and 0.16 to 0.22 on plaster models. It is known that the Dahlberg's method does not take into account the size of the error in relation to the magnitude of the variable itself. However, the errors of the magnitude in this study are regarded as relatively low.[15]

An SPSS statistical package program for Windows was used for the evaluation of measurements. The Wilcoxon paired 2-sample test evaluated the average differences between pretreatment and post-treatment (T1-T2), pretreatment and postretention (T1-T3), and post-treatment and postretention (T2-T3).

RESULTS

Lateral cephalometric results

Table 2 shows the T1 to T2 changes. Significant increases were found in the SN-MP, ANS-Me, and PP⊥U1 variables ($P < .05$), the ANB and SN⊥U6 variables ($P < .01$), and the MP-PP variable ($P < .001$). Significant decreases were found in the U1P-SN and SV⊥U1 variables ($P < .05$) and the SNB and SV⊥B variables ($P < .01$).

Table 3 shows the T1 to T3 changes. Significant increases were found in the SN-MP, ANS-Me, PP⊥U1, and SN⊥U6 variables ($P < .05$) and the MP-PP variable ($P < .01$). Significant decreases were found in the SV⊥B, U1P-SN, and SV⊥U1 variables ($P < .05$) and the SNB variable ($P < .01$).

Table 4 shows the T2 to T3 changes. Significant decreases were found in the SNA, ANB, and SV⊥A variables ($P < .05$).

Frontal cephalometric results

Table 2 shows the T1 to T2 changes. Significant increases were found in the JL-JR variable ($P < .01$) and the 6A-A6, ML, and MR variables ($P < .001$).

TABLE 4. Comparison of the T2–T3 Periods†

		T2 Period				T3 Period					
	Measurements	X	SD	Min	Max	X	SD	Min	Max	P	Test
Lateral Cephalometric Film											
1	SNA	78.62	3.52	74.00	86.00	77.84	3.30	73.00	85.00	0.0454	*
2	SNB	74.94	3.33	70.00	83.00	75.41	3.19	71.00	83.00	0.1422	NS
3	ANB	3.69	2.24	1.00	9.00	2.44	2.07	−1.00	6.00	0.0144	*
4	SN-MP	42.16	5.09	33.50	48.50	41.78	4.52	33.00	48.00	0.1579	NS
5	NS-PP	9.34	3.25	2.00	14.00	9.38	2.92	5.50	14.00	0.6496	NS
6	MP-PP	32.81	4.20	26.50	38.00	32.41	4.55	26.00	38.00	0.0546	NS
7	SN-PNS	45.81	2.26	42.00	50.00	45.75	2.11	43.00	50.00	0.7353	NS
8	SV-A	56.59	2.26	42.00	50.00	55.69	4.87	48.00	63.00	0.0454	*
9	SV-B	41.66	7.09	32.00	54.00	41.94	8.00	32.00	55.00	0.6101	NS
10	N-ANS	54.75	2.63	51.00	59.00	54.69	2.82	50.00	61.00	0.9057	NS
11	ANS-Me	71.75	4.23	65.00	82.00	71.50	5.00	91.00	106.00	0.5303	NS
12	U1P-SN	98.19	5.30	90.00	107.00	99.88	5.23	91.00	106.00	0.1556	NS
13	L1P-MP	84.34	5.29	73.00	91.00	84.94	5.96	74.00	94.00	0.1731	NS
14	PP-U1	31.09	2.20	27.50	35.00	30.72	2.45	26.00	35.00	0.0663	NS
15	SN-U6	73.44	3.29	69.00	81.00	73.06	2.84	69.00	79.00	0.0759	NS
16	SV-U1	54.75	2.63	51.00	59.00	54.69	2.82	50.007	61.00	0.3739	NS
17	Overjet	3.00	1.63	0.00	7.00	2.69	1.46	0.00	5.00	0.1386	NS
18	Overbite	−0.25	2.12	−4.00	4.00	−0.13	2.02	−4.00	4.00	0.5147	NS
Frontal Film											
1	NC-CN	32.75	2.72	29.00	39.00	32.66	3.01	29.00	41.00	0.7223	NS
2	JL-JR	66.31	3.72	58.00	74.00	66.06	3.92	57.00	74.00	0.0679	NS
3	6A-A6	66.25	3.47	61.00	71.00	65.44	3.20	60.00	70.00	0.0159	*
4	ML angle	93.94	7.60	80.00	106.00	91.31	7.20	78.00	103.00	0.0010	**
5	MR angle	92.13	11.79	68.00	118.00	88.31	10.77	66.00	111.00	0.0010	**
Model											
1	Upper interpremolar width	38.61	2.80	34.50	45.60	38.21	2.87	33.00	45.50	0.0454	*
2	Upper intermolar width	51.43	2.96	45.00	55.60	50.98	3.13	43.00	55.00	0.0117	*
3	Lower intermolar width	41.91	2.71	35.00	45.00	41.81	2.69	35.00	45.00	0.2249	NS

$P < .05$*. $P < .01$**. $P < .001$***. Significant P values are shown.
† X indicates mean; SD, standard deviation; Min, minimum; and Max, maximum.

Table 3 shows the T1 to T3 changes. Significant increases were found in the JL-JR, ML, and MR variables ($P < .01$) and the 6A-A6 variable ($P < .001$).

Table 4 shows the T2 to T3 changes. Significant decreases were found in the 6A-A6 variable ($P < .05$) and the ML and MR variable ($P < .01$).

Table 5 shows the differences between the JL-JR and 6A-A6 widths and the JL-JR/6A-A6 ratio at the T1-T2, T1-T3, and T2-T3 periods. Figure 6 shows a bar graph of the variables of the JL-JR and 6A-A6 widths on the T1, T2, and T3 periods.

Table 6 shows the differences of the ML and MR angles on the T1-T2, T1-T3, and T2-T3 periods. Figure 7 show a bar graph of the variables of the ML and MR angle on the T1, T2, and T3 periods.

Periapical film results

Periapical films were taken at the T1, T2, and T3 time periods. Evidence of sutural expansion was evaluated by the presence of increased radiolucency in the sutural area. Table 7 shows the results of the analysis of periapical films. Opening of the midpalatal suture was demonstrated in four patients. Slight opening of the midpalatal suture was observed in four other patients whereas no evidence of the sutural opening was shown in eight patients. Figures 8–10 show the periapical films at T1, T2, and T3 periods for the patients treated with NME.

TABLE 5. The Differences of the JL-JR and 6A-A6 Widths and the JL-JR/6A-A6 Ratio at the T1-T2, T1-T3, and T2-T3 Periods

	Difference of the T1-T2	Difference of the T1-T3	Difference of the T2-T3
JL-JR	2.5 (3.91%)	2.25 (3.53%)	0.25 (0.39%)
6A-A6	9.2 (16.17%)	8.41 (14.75%)	0.81 (1.42%)
JL/JR/6A-A6 ratio	3.69	3.74	3.24

Plaster model results

Table 2 shows T1 and T2 changes. Significant increases were found in the lower intermolar width variable ($P < .01$). The upper interpremolar and intermolar widths variables also increased ($P < .001$). Table 3 shows T1 and T3 changes. Significant increases were found in upper interpremolar and intermolar widths variables ($P < .001$). Table

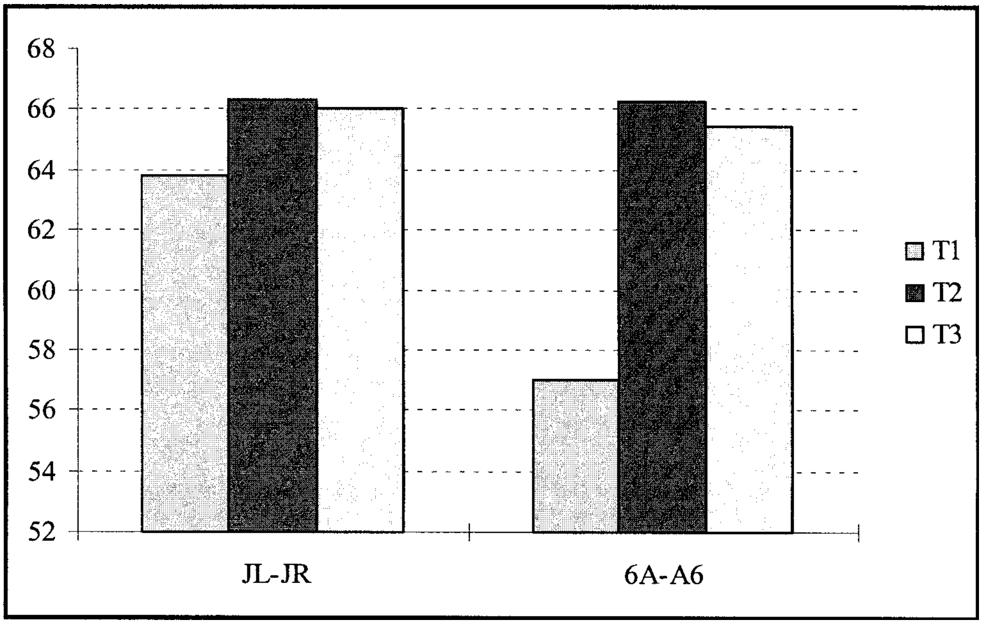

FIGURE 6. The variables of the JL-JR and 6A-A6 widths on the T1, T2, and T3 periods.

TABLE 6. Differences of the ML and MR Angles on the T1-T2, T1-T3, and T2-T3 Periods

	Difference of the T1-T2	Difference of the T1-T3	Difference of the T2-T3
ML angle	8, 19	5, 56	2, 63
MR angle	7, 63	3, 81	3, 81

4 shows T2 and T3 changes. Significant decreases were found in upper interpremolar and intermolar widths variables ($P < .05$).

Table 8 shows the differences of the upper interpremolar and upper intermolar widths in the T1-T2, T1-T3, and T2-T3 periods and upper intermolar width/upper interpremolar widths ratio. Figure 11 shows the variables of the upper interpremolar and intermolar widths in the T1, T2, and T3 periods.

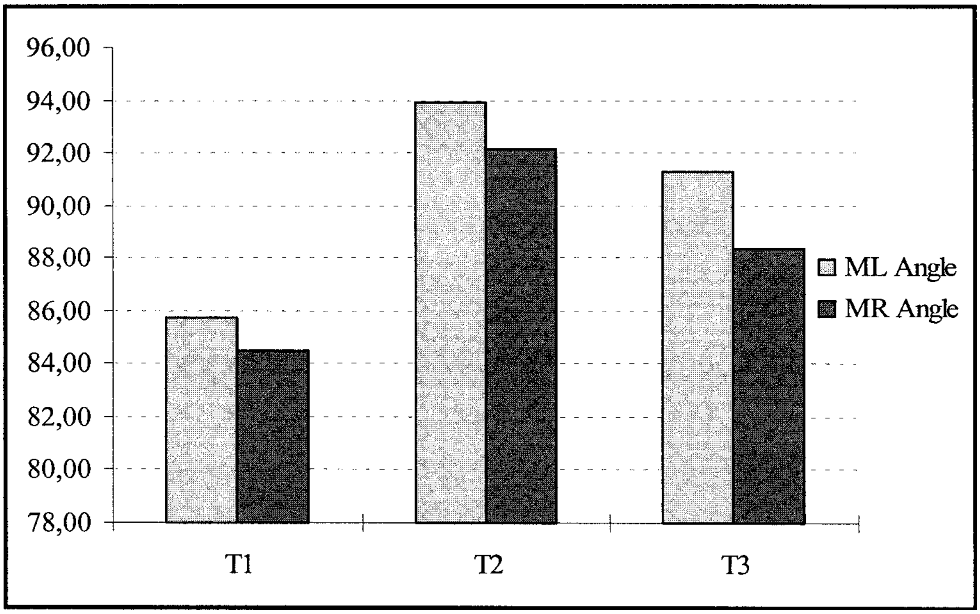

FIGURE 7. The variables of the ML and MR angles on the T1, T2, and T3 periods.

TABLE 7. Variations of the Midpatal Suture According to Mean Age of the Patients*

Patient No.	Sex	Mean Age	Group 1	Group 2	Group 3
1	Male	14.04			*
2	Male	15.92			*
3	Male	13.61		*	
4	Female	11.95	*		
5	Female	13.51			*
6	Male	15.81			*
7	Female	15.85			*
8	Female	12.97	*		
9	Female	12.36			*
10	Female	14.59		*	
11	Female	14.63			*
12	Female	12.89	*		
13	Female	14.74		*	
14	Female	12.27			*
15	Female	12.14	*		
16	Female	13.15		*	
			4	4	8

* In Group I, there is an obvious radiographic separation of the midpalatal suture, in Group II, there is a less obvious radiographic separation of the midpalatal suture; and in Group III, there is no radiographic separation of the midpalatal suture.

DISCUSSION

Conventional rapid maxillary expanders (Haas, Hyrax, Minne Expander, Cap Splint, and Acrylic Bonded Appliance) are uncomfortable, require patient cooperation, and rely on labor-intensive laboratory production. They are inefficient because of the intermittent nature of their force application and also unable to correct maxillary first molar rotation.[9–11,16]

A tandem-loop nickel titanium temperature-activated maxillary expansion appliance was developed that produces light continuous pressure on the midpalatal suture, molar rotation and distalization and requires little cooperation or laboratory work.[9]

The aim of this study was to evaluate the effects of a Nickel-titanium maxillary expander on dentofacial structures. Many investigators suggest that expansion should be done in the prepubertal period or during puberty. Skeletal and dental effects are obtained more easily and relapse is rare.[4,7,17–19] In our study, the mean age of the patients was 13.8 years and the expansion and retention periods were 3.6 and 2.6 months, respectively. All patients had bilateral cross bites and permanent dentitions.

When the NME was first placed, the Ortholoy (GAC, Central Islip, NY) arms did not contact the bicuspids. As soon as the molars rotated, moved distally 1–3 mm, and expanded, the arms touched the bicuspids. The appliance initially appeared to move palatally, but as it expanded it moved occlusally. This produced a lower tongue posture that can promote expansion and transverse growth in the mandibular arch. After expansion, buccal root torque was introduced into the wire with a plier and the wire was inserted into the lingual sheath.[9–10] In this study, the application of the NME was performed according to the manufacturer's directions.

Lateral cephalometric evaluation

In this study, when the T1, T2, and T3 variables of SNA and SN-PP angles and SV-A, SN-PNS, and N-ANS dimensions were examined, the maxilla was not affected vertically or sagitally (Tables 3–5). The reason for this is that, with increasing age, the mechanical locks between the sutures of the maxilla and the surrounding nasomaxillary bones are increased. As long as the amount of force exerted by the NME is within physiological limits, one can assume that it is not effective in these sutures. This view is consistent with the results of Arndt,[9] Marzban and Nanda[16] and Cimbotti et al.[10]

While the SNB angle and the SV-B dimension decreased, theANB angle increased. The SN-MP and MP-PP angles and the ANS-ME and SN-U6 dimensions also increased (Tables 3–5). These variables show downward and backward rota-

FIGURE 8. (a) Midpalatal suture on the T1 period; (b) opening midpalatal suture on the T2 period; and (c) midpalatal suture on the T3 period.

FIGURE 9. (a) Midpalatal suture on the T1 period; (b) slightly opening midpalatal suture on the T2 period; and (c) midpalatal suture on the T3 period.

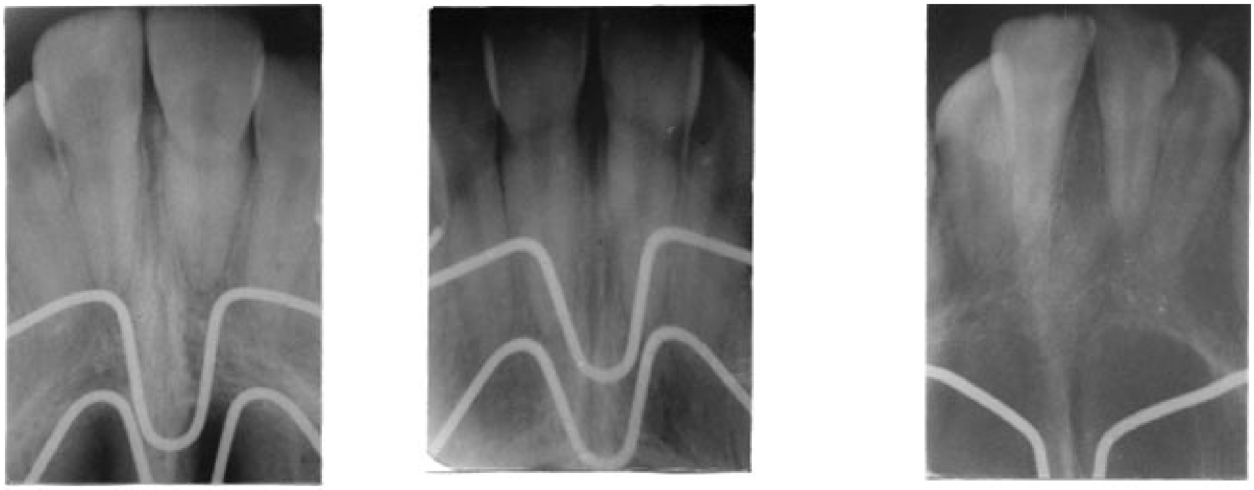

FIGURE 10. (a) Midpalatal suture on the T1 period; (b) no evidence of the sutural opening on the T2 period; and (c) midpalatal suture on the T3 period.

TABLE 8. Differences of the Interpremolar and Intermolar Widths on the T1-T2, T1-T3, and T2-T3 Periods and Upper Intermolar Width/Upper Interpremolar Widths Ratio

	Difference of the T1-T2	Difference of the T1-T3	Difference of the T2-T3
Upper interpremolar width	9.09 (30.79%)	8.69 (29.44%)	0.25 (1.36%)
Upper intermolar width	9.95 (23.99%)	9.50 (22.99%)	0.81 (1.08%)
Interpremolar width/intermolar width ratio	1.095	1.093	1.125

tion of the mandible and an increased lower face height due to buccal tipping of the first molars and extrusion of palatal cusps during the expansion period. These findings are consistent with findings of many investigators.[4,6,7,17,20]

A decrease in the U1P-SN angle and the SV-U1 dimension were observed while the PP⊥U1 dimension increased (Tables 3–5). These variables showed upper incisor retrusion and extrusion. The appliance initially appeared to move palatally, but as it expanded, it moved occlusally producing a lower tongue posture. This caused an alteration in tongue-lip balance and lip pressure that inclined the upper incisors backward. Many investigators have shown backward inclination and extrusion of upper incisors following expansion therapy.[7,17,20,21]

Frontal cephalometric evaluation

No significant difference was found in the width of the nasal cavity, NC-CN. Other studies have shown no signif-

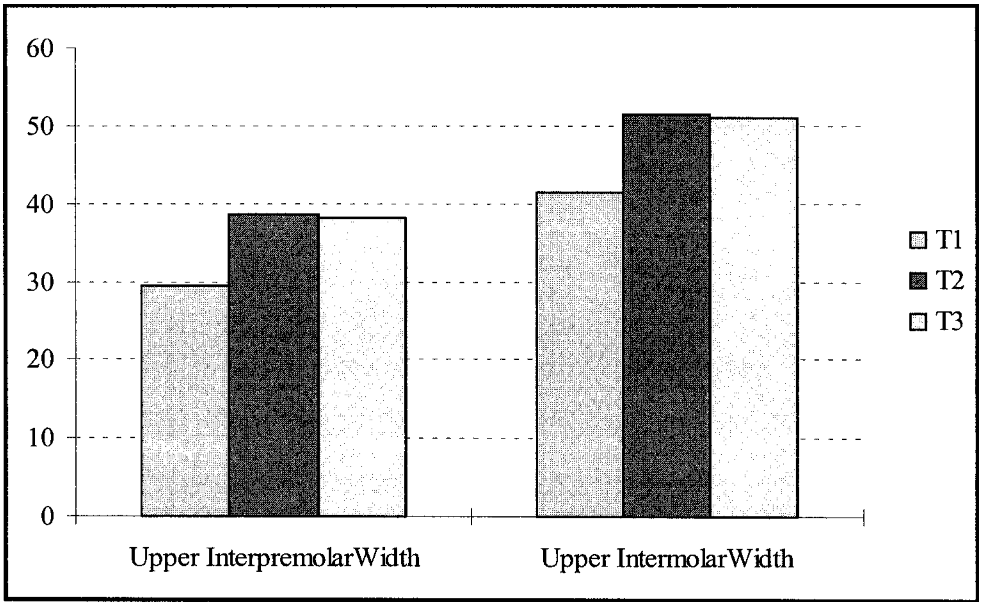

FIGURE 11. The variables of the interpremolar and intermolar widths on the T1, T2, and T3 periods.

icant changes in the width of the nasal cavity after slow maxillary expansion.[2,5,22]

Skeletal width (JL-JR width) increased significantly in the T1-T2 period and was not a part of any post-retention relapse. While the amount of skeletal width increase during T1-T3 averaged 2.25 mm (3.53%), relapse during T2-T3 averaged 0.25 mm (0.38%) (Table 6, Figure 6).

The intermolar width (6A-A6 width) increased significantly after expansion and showed a significant post-retention relapse. While the amount of intermolar width increase during T1-T3 averaged 8.41 mm (14.75%), a mean relapse (T2-T3) of 0.81 mm (1.42%) was seen (Table 6, Figure 6).

The ratio of increases in the skeletal width to increases in the intermolar width showed that the intermolar width expanded more than the skeletal width (Table 6). The inclination of the upper first molars, as shown by the ML-MR angles, showed significant buccal tipping following expansion and significant post-retention relapse. Hicks[5] and Cotton[2] reported 2° to 24° of buccal molar tipping with use of slow expansion appliances. Marzban and Nanda,[16] Ciambotti et al,[10] and Altuntaş et al[23] determined the different amounts of buccal molar tipping with the use of NME. Many investigators stated that with any expansion procedure, overexpansion is necessary to compansate for the tendency of the posterior teeth to return to their pretreatment axial inclination.[3,5,8]

Periapical film evaluation

Opening of the midpalatal suture was demonstrated in four patients, slight opening of the midpalatal suture in another four patients, and no evidence of suture opening in the other eight patients (Table 7). These results suggest that NME produces slow continuous forces and physiologic sutural adjustment may occur, leading to bony deposition as expansion occurs. Other radiographic studies with slow expansion appliances reported similar findings, with evidence of midpalatal suture separation shown in 50% to 80% of the patients.[11,19,21]

Plaster model evaluation

Interpremolar width increased significantly during expansion but there was significant post-retention relapse. While the amount of the interpremolar width (T1-T3) averaged 8.68 mm (28.44%), relapse (T2-T3) averaged 0.25 mm (1,36%) (Table 8, Figure 11).

Intermolar width increased significantly after expansion but there was significant post-retention relapse. While the amount of intermolar width expansion (T1-T3) averaged 8.50 mm (22.88%), relapse (T2-T3) averaged 0.81 mm (1.08%) (Table 6, Figure 6).

The ratio of changes in the intermolar width to the interpremolar width showed that expansion was almost at the same ratio (Table 8). Interpremolar and intermolar width changes reflected the total amount of dental and alveolar expansion produced by the NME. Similar results were reported by other studies that used NME.[9–11,16,23,25]

Lower intermolar width increased significantly after expansion and did not undergo post-retention relapse. The mandibular buccal segment gradually became upright and eliminated dental compensation from the pre-existing crossbite. This result was reported by Mazban and Nanda[16] and Altuntaş et al.[23]

Clinical evaluation

Application of NME had the following results:

a. Posterior crossbites were corrected in all patients.

b. Mesiolingual rotations of the maxillary first molars were corrected.
c. Slightly distal movement was seen in upper first molars.
d. No notable pain or discomfort was reported during the course of NME.
e. The appliance was hygienic.
f. Less patient cooperation was needed.
g. The appliance was placed in a short time without laboratory procedures and did not require frequent operator or patient adjustment.

In conclusion, NME provides a viable alternative to other slow maxillary expansion appliances or rapid expansion appliances for the correction of transverse discrepancies. The clinican's choice of expander will depend on his or her initial diagnosis and treatment goals.

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