Original Article

A Comparison of the Effects of Rapid Maxillary Expansion and Fan-Type Rapid Maxillary Expansion on Dentofacial Structures

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Abstract: The aim of this study was to evaluate and compare the sagittal, transverse, and vertical effects of rapid maxillary expansion (RME) and fan-type RME on dentofacial structures. The study group consisted of 34 patients, 14 boys and 20 girls (average age 12.5 years), selected without considering their skeletal class and sex. The fan-type RME group comprised 17 subjects, who had an anterior constricted maxilla with a normal intermolar width. The RME group comprised 17 other subjects, who had a maxillary transverse discrepancy with a posterior crossbite. The records obtained for each patient included a lateral and a frontal cephalometric film, upper plaster models, and occlusal radiograph obtained before treatment (T1), after expansion (T2), and immediately after a three-month retention period (T3). The data obtained from the evaluation of the records before and after treatment, after treatment and after retention, and before treatment and after retention were compared using paired *t*-test. Further comparisons between the groups were made using Student's *t*-test. There was significantly greater expansion in the intercanine than in the intermolar width in the fan-type RME group as compared with the RME group. Downward and forward movement of the maxilla was observed in both groups. The upper incisors were tipped palatally in the RME group, but they were tipped labially in the fan-type RME group. There was significantly greater expansion in the nasal cavity and maxillary width in the RME group as opposed to the fan-type RME group. (*Angle Orthod* 2004;74:184–194.)

Key Words: Rapid maxillary expansion; Fan-type rapid maxillary expansion; Bonded RME appliances; Intercanine and intermolar width change

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INTRODUCTION

Rapid maxillary expansion (RME) is accomplished by applying a laterally directed force against the teeth or palatal mucosa, or both, resulting in a widening of the midpalatal suture.[1] The RME appliance has been in the orthodontic literature since 1860 when Angell[2] described its use in treating maxillary deficiency. Since then, numerous researchers have tried and discarded this method.

The RME expander as described by Haas[3] is a tissue-borne fixed split acrylic maxillary expansion appliance. Because the appliance commonly produces orthopedic forces in the range of 3 to 10 pounds,[4] the expansion was deemed to be skeletal and, therefore, more stable.[3]

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The Hyrax or Biederman RME appliance is a commonly used type of RME appliance.[5] It is tooth borne and consists of a screw with heavy wire extensions that are soldered to the palatal aspects of the bands on the first molars and premolars.

Isaacson's Minne expander appliance is a special spring-loaded appliance adapted to the first permanent molar bands. It could be reduced in length to adapt narrow maxilla by shortening the spring, tube, and rod.[6]

Derichsweiler[7] claimed an increase in nasal width, lowering of the palatal vault, and straightening of the nasal septum due to the RME allowing many mouth breathers to adapt to the use of the nasal passages for respiration. The maxilla comprises the external walls of the nasal cavity laterally, and expansion results in an increase in the internasal capacity.

During expansion, bending of the alveolar structures and buccal tipping of the posterior maxillary teeth lead to posterior rotation of the mandible, open bite, and an increased vertical face dimension.[3,8–14]

In orthodontic practice, there are often cases in which narrowing of the upper arch occurs only in the anterior region. Many kinds of appliances have been used to try to gain more expansion in the intercanine area. However, all these appliances were removable and only expand the maxilla dentally. In 1996, Schellino et al [15] designed a spider screw named ''Ragno,'' which works asymmetrically and allows ''fan opening.'' The development of a rapid-expansion appliance, which only affects the anterior region of the maxilla, certainly represents a significant improvement in conventional RME appliances. It avoids undesired expansion of the maxilla in the region of the upper first and second premolars, which creates an advantage in the future treatment of the case.

Levrini and Filippi[16] used a Ragno appliance to expand the maxilla in a study involving a six-year-old male with bilateral cleft lip and palate that required RME only at the anterior region. Posttreatment plaster models revealed that the intercanine width increased more than intermolar width, which was different from previous studies.

Sadeddin[17] evaluated the effect of a fan-type RME on anteriorly constricted cases. He found significantly greater expansion in the intercanine width than in the intermolar width, increase in upper arch parameter, and downward and forward movement of the upper arch in addition to clockwise movement of the mandible.

The aim of this study was to compare the sagittal, transverse, and vertical effects of an acrylic-bonded RME device on maxillary restricted cases with those of a fan-type acrylic-bonded RME device on anterior constricted maxillary cases with normal intermolar width.

MATERIALS AND METHODS

The study involved 34 patients, 14 boys and 20 girls, who were treated in the Department of Orthodontics of Cumhuriyet University. Lateral and frontal cephalometric films and upper plaster models were obtained before treatment (T1), after treatment (T2), and after three months of retention (T3). The patients were selected without considering their skeletal properties or sex and were divided into two groups. Group I consisted of 17 patients (7 boys and 10 girls), who had an anteriorly constricted maxillary arch (V shaped), normal intermolar width, and no crossbite in the posterior region (Table 1).

A fan-type acrylic-bonded fully tooth- and tissue-borne RME appliance was used to correct the anterior narrowness (Figure 1). The Ragno screw (Leone, Florence, Italy) was placed in the acrylic plate parallel to the occlusal plane of the upper teeth. The hinge point of the screw was positioned tangent to the distal surfaces of the upper first permanent molars. The anterior arms of the screw were bent mesially, and the posterior arms were bent perpendicular to the screw body to standardize the position of the jackscrew (Figure 2).

Group II consisted of 17 patients (7 boys and 10 girls), who had presented with posterior crossbites (Table 1). An acrylic-bonded fully tooth- and tissue-borne RME appliance (Figure 3) containing a Hyrax screw (Dentaurum, Pforzheim, Germany) was positioned parallel to the second premolars (Figure 4) and used to correct the posterior crossbite.

The acrylic part of the appliance extended over the oc-

TABLE 1. Distribution of Sex, Age, Expansion Time, and Retention Time for the Study Groups

	n	Age, Mean (y)	Expansion Period, Mean (d)	Retention Period, Mean (d)
Group I				
Male	7	11.8 ± 1.6	24 ± 2.1	90.1 ± 7.6
Female	10	12.5 ± 0.7	23.7 ± 2	89.4 ± 8.9
Total	17	12.2 ± 1.1	23.9 ± 2.1	90 ± 8
Group II				
Male	7	12.5 ± 1.4	26.5 ± 2.1	87.5 ± 10.6
Female	10	12.8 ± 1.1	26.4 ± 2.3	90.8 ± 6.5
Total	17	12.7 ± 1.1	26.47 ± 2.85	90.4 ± 6.7

FIGURE 1. Fan-type RME screw on plaster model after bending.

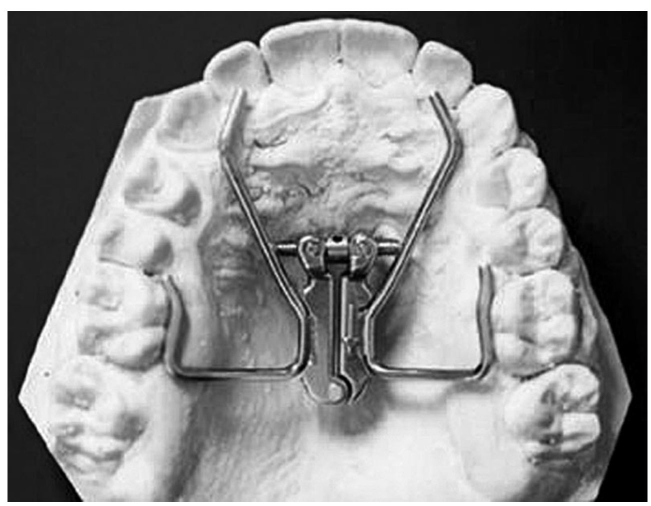

FIGURE 2. Hyrax screw on plaster model after bending.

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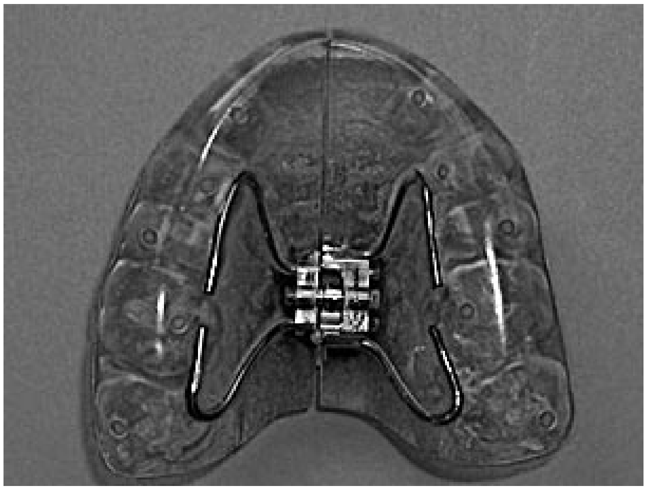

FIGURE 3. Fan-type acrylic-bonded RME appliance.

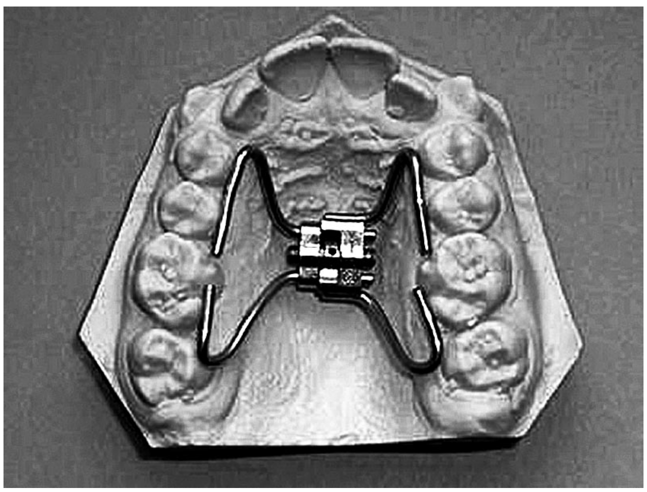

FIGURE 4. Acrylic-bonded RME appliance.

clusal and middle third of the vestibular surfaces of all teeth. The thickness of the occlusal acrylic surface was limited to the freeway space and was in contact with all lower teeth. Holes were opened for the escape of excess cement during cementation. The appliances were activated with one-fourth twice per day in both groups. Patients and parents were advised to discontinue expansion if pain or tissue swelling was felt.

In group I, expansion was considered complete when a premolar cusp of overcorrection at the first premolar area was achieved. In group II, expansion was considered complete when the occlusal aspect of the maxillary lingual cusp of upper first molars contacted the occlusal aspect of the facial cusp of the mandibular first molars. At that time the screw was fixed with 0.014-inch ligature wire, and the appliance was left for one week to minimize discomfort during removal. After removal, the appliance used in active treatment was cleaned and reused as a removable retention appliance. After a mean of 90.02 days of retention for

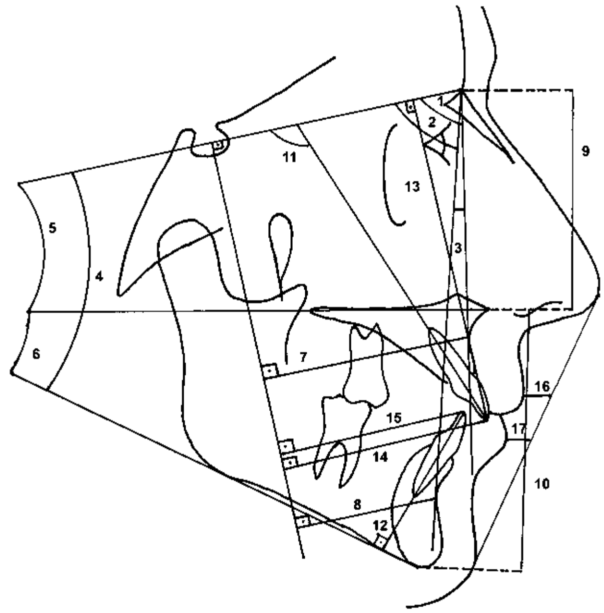

FIGURE 5. Lateral cephalometric measurements: 1, SNA; 2, SNB; 3, ANB; 4, SN-MP; 5, SN-PP; 6, PP-MP; 7, SV ⊥ A; 8, SV ⊥ B; 9, N-ANS; 10, ANS-Me; 11, U1P-SN; 12, L1P-MP; 13, SN ⊥ U1; 14, SV ⊥ U1; 15, SV ⊥ L1; 16, UL-E; and 17, LL-E.

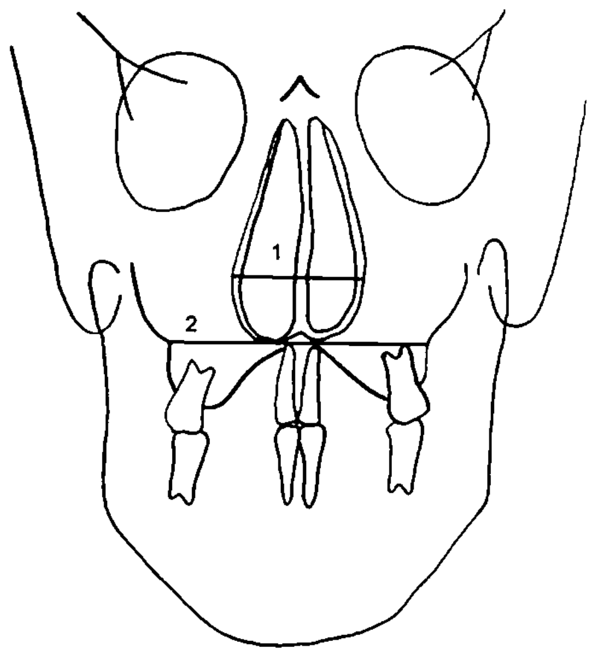

FIGURE 6. Frontal cephalometric measurements: 1, NC-CN (nasal cavity width); 2, JL-JR (maxillary width).

group I and 90.47 days for group II, the postretention records were taken, and the patients' routine orthodontic treatment was continued.

The measurements used in the study are shown in Figures 5 through 7. The maxillary arch width was recorded between the right and left canines and permanent first molars on the T1, T2, and T3 models. Intermolar dimensions

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were measured between the deepest points of central sulci of the upper first molar teeth. The intercanine width was measured between the incisal tips of the canines.

Measurement error and statistical analysis

To evaluate the measurement error in landmark identification and location, 20 randomly selected lateral and frontal cephalometric films and[18] upper plaster models were remeasured. The same films and casts were measured after a one-month interval, and the method error was calculated according to Dahlberg's formula ($\sqrt{\Sigma d2/2n}$).[19] The d in the formula represents the difference between two measurements, and n represents the number of double measurements.

The results were calculated using the software SPSS for Windows (release 10.0.0, SPSS Inc., Chicago, Ill). The arithmetic mean and standard deviation between the pretreatment and posttreatment (T1 and T2) measurements, the posttreatment and postretention (T2 and T3) measurements, and the pretreatment and postretention (T1 and T3) measurements were all studied using the paired *t*-test. The time interval between T1 and T2 did not exceed 30 days, which virtually eliminated growth as a variable. The differences between the groups were evaluated using a Student's *t*-test.

RESULTS

The measurement errors were calculated to vary from 0.253 to 0.857 and were nonsignificant. The pretreatment (T1) and posttreatment (T2) measurements, the posttreatment (T2) and postretention (T3) measurements, and the pretreatment (T1) and postretention (T3) measurements are presented in Tables 2 through 4.

Clinical findings

All the patients demonstrated sutural opening, which was confirmed by an occlusal radiograph. A median diastema between the central incisors developed during treatment, and no problems were reported by any of the patients in either group.

Lateral cephalometrics

Pretreatment vs posttreatment (T1 vs T2). Differences between pretreatment and posttreatment are shown in Table 2. Group I showed increases for SNA, ANB, SN-MP, SV ⊥ A, N-ANS, U1P-SN, SN ⊥ U1, and SV ⊥ U1 ($P < .001$); SN-PP and ANS-Me ($P < .01$); and UL-E ($P < .05$). Treatment was associated with a reduction for SNB that was not significant ($P < .01$).

Group II presented with increases for SNA, ANB, and SN-MP ($P < .001$); MP-PP, SV ⊥ A, and ANS-Me ($P < .01$); and N-ANS ($P < .05$). Treatment was associated with reductions for SNB and SV ⊥ B ($P < .05$).

When the differences between the groups were compared using Student's *t*-test (Table 2), group I showed a significantly greater increment for U1P-SN and SN ⊥ U1 ($P < .001$) and SN-PP and SV ⊥ U1 ($P < .01$) when compared with group II.

Posttreatment vs postretention (T2 vs T3). Differences between posttreatment and postretention are shown in Table 3. Group I showed a reduction in SNA, ANB, SN-MP, and SV ⊥ A ($P < .001$); SN ⊥ U1 and SV ⊥ U1 ($P < .01$); MP-PP and N-ANS ($P < .05$); and an increase for SV ⊥ B ($P < .05$).

Group II showed reductions for ANB and SN-MP ($P < .01$) and an increase for SV ⊥ B ($P < .01$).

When the differences between the groups were compared using Student's *t*-test (Table 3), group I showed a significant reduction for the values SNA and ANB ($P < .001$) and SN-MP and SV ⊥ A ($P < .05$) when compared with group II.

Pretreatment vs postretention (T1 vs T3). Differences between pretreatment and postretention are shown in Table 4. Group I presented with increases in SNA, ANB, SV ⊥ A, U1P-SN, SN ⊥ U1, and SV ⊥ U1 ($P < .001$) and SN-MP, SN-PP, N-ANS, SV ⊥ L1, and UL-E ($P < .01$).

Group II presented with increases in SNA, ANB, and SN-MP ($P < .001$); MP-PP, SV ⊥ A, and ANS-Me ($P < .01$); and N-ANS ($P < .05$); and reduction for SNB ($P < .05$) (Table 4).

The differences between the groups were compared using Student's *t*-test (Table 4). The mean differences for group I were larger than the means for group II for the values U1P-SN ($P < .001$); SV ⊥ U1 ($P < .01$); and SN-PP, ANS-Me, SN-U1, and UL-E ($P < .05$).

Frontal cephalometrics

Pretreatment vs posttreatment (T1 vs T3). The differences between pretreatment and posttreatment are shown in Table 2. Group I showed increases for both nasal cavity width (+2.41 mm) ($P < .001$) and maxillary width (+0.41 mm) ($P < .01$).

Group II showed increases for nasal cavity width (+3.5 mm) and maxillary width (+4.94 mm) ($P < .001$).

The differences between the groups were compared using Student's *t*-test (Table 2). Group II showed a significantly greater increase for both nasal cavity width and maxillary width when compared with group I ($P < .001$).

Posttreatment vs postretention (T2 vs T3). Differences between posttreatment and postretention are shown in Table 3. Group I showed a reduction for nasal cavity width (−0.47 mm) ($P < .01$).

Pretreatment vs postretention (T1 vs T3). Differences between posttreatment and postretention are shown in Table 4. Group I showed an increase for nasal cavity width (+1.94 mm) ($P < .001$) and maxillary width (+0.29 mm) ($P < .05$). Group II showed an increase for nasal cavity width (+3.35 mm) and maxillary width (+4.86 mm) ($P < .001$).

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TABLE 2. Changes and Comparisons of Pretreatment and Posttreatment Values Between and Within the Groups

		Group I						
		Pretreatment (T1)		Posttreatment (T2)		Difference (T2 − T1)		
		Mean	SD	Mean	SD	Mean	SD	Paired *t*-test
1	SNA (°)	78.35	2.89	80.47	2.67	2.12	0.70	0.000***
2	SNB (°)	75.76	2.28	75.23	2.11	−0.53	0.94	0.034*
3	ANB (°)	2.59	2.79	5.29	2.26	2.70	1.05	0.000***
4	SN-MP (°)	37.53	5.39	39.29	5.43	1.76	1.25	0.000***
5	SN-PP (°)	8.94	1.92	9.88	2.23	0.94	1.03	0.002***
6	MP-PP (°)	27.35	7.96	29.59	4.80	2.24	4.92	0.079 NS[a]
7	SV⊥A (mm)	56.41	3.99	58.71	4.16	2.29	0.77	0.000***
8	SV⊥B (mm)	43.00	5.12	42.71	5.10	−0.29	1.31	0.369 NS
9	N-ANS (mm)	54.59	3.12	56.00	3.16	1.41	1.18	0.000***
10	ANS-Me (mm)	65.24	3.51	66.29	3.67	1.05	1.25	0.003***
11	U1P-SN (°)	100.18	6.90	104.29	6.35	4.12	2.26	0.000***
12	L1P-MP (°)	90.94	6.00	91.06	5.91	0.12	0.70	0.496 NS
13	SN⊥U1 (mm)	82.65	3.59	84.71	3.50	2.06	1.03	0.000***
14	SV⊥U1 (mm)	56.35	6.33	59.53	5.70	3.18	1.29	0.000***
15	SV⊥L1 (mm)	52.59	3.76	52.82	4.17	0.24	1.15	0.410 NS
16	UL-E (mm)	−2.41	2.65	−1.59	1.62	0.82	1.59	0.049*
17	LL-E (mm)	−1.82	1.88	−1.94	1.68	−0.12	1.36	0.727 NS
18	NC-CN (mm)	34.41	1.91	36.82	1.98	2.41	0.71	0.000***
19	JL-JR (mm)	60.18	1.74	60.58	1.90	0.41	0.51	0.004**
20	Upper intercanine width (mm)	32.94	2.28	41.06	2.66	8.12	1.45	0.000***
21	Upper intermolar width (mm)	45.76	2.28	48.41	2.21	2.65	0.61	0.000***

[a] NS indicates nonsignificant.
* $P < .05$, ** $P < .01$, *** $P < .001$.

The differences between the groups were compared using Student's *t*-test (Table 4). Group II showed significantly greater increase for both nasal cavity width and maxillary width when compared with Group I ($P < .001$).

Transverse dental evaluations

Pretreatment vs posttreatment (T1 vs T2). Differences between pretreatment and posttreatment are shown in Table 2. Group I showed an increase for both upper intercanine width (+8.12 mm) and intermolar width (+2.65 mm) ($P < .001$). In group II, the posttreatment values also were greater than the pretreatment values for both upper intercanine width (+6.06 mm) and intermolar width (+6.77 mm) ($P < .001$).

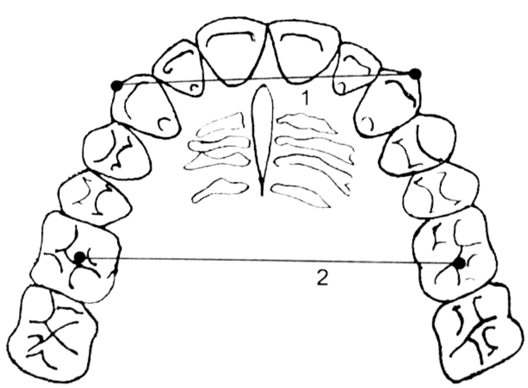

FIGURE 7. Transverse dental evaluations: 1, upper intercanine width and 2, upper intermolar width.

The differences between the groups were compared using Student's *t*-test (Table 2). Group I presented with significantly greater increments for upper intercanine width ($P < .01$) and conserved the upper intermolar width ($P < .001$) when compared with group II.

Posttreatment vs postretention (T2 vs T3). Differences between posttreatment and postretention are shown in Table 3. Group I showed a decrease for both upper intercanine width (−1.94 mm) and intermolar width (−0.76 mm) ($P < .001$). No statistically significant differences were found between posttreatment and postretention for the upper intercanine width and intermolar width in group II.

Pretreatment vs postretention (T1 vs T3). Differences between posttreatment and postretention are shown in Table 4. Group I showed an increase for both intercanine width (+6.18 mm) and intermolar width (+1.88 mm) ($P < .001$). Group II showed an increase for intercanine width (+5.91 mm) and intermolar width (+6.68 mm) ($P < .001$).

The differences between the groups were compared using Student's *t*-test (Table 4). The amount of increase in maxillary width was significantly greater in group I when compared with group II ($P < .001$).

DISCUSSION

Acrylic-bonded fully tooth- and tissue-borne expanders provide effective palatal expansion for patients, without the use of orthodontic bands. Although banded expansion appliances are also effective, they are more complicated to

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TABLE 2. Extended

Group II							
Pretreatment (T1)		Posttreatment (T2)		Difference (T2 − T1)			
Mean	SD	Mean	SD	Mean	SD	Paired *t*-test	Student's *t*-test
78.09	3.70	79.53	3.15	1.44	1.37	0.000***	0.079 NS
76.03	2.91	75.29	2.87	−0.74	1.16	0.019*	0.574 NS
2.06	2.32	4.24	1.97	2.18	1.27	0.000***	0.195 NS
39.09	7.26	40.94	7.17	1.85	1.37	0.000***	0.846 NS
9.65	2.66	8.94	2.34	−0.71	1.87	0.139 NS	0.004**
29.50	6.52	30.71	6.60	1.21	1.36	0.002**	0.412 NS
50.91	6.54	52.56	6.56	1.65	2.01	0.004**	0.224 NS
38.26	9.58	37.18	10.04	−1.09	1.74	0.020*	0.143 NS
55.32	3.25	56.62	3.44	1.30	2.39	0.040*	0.857 NS
68.56	4.63	71.15	5.56	2.59	3.10	0.003**	0.069 NS
103.71	7.28	102.50	6.07	−1.21	3.83	0.213 NS	0.000***
89.71	4.47	89.56	5.00	−0.15	3.20	0.852 NS	0.741 NS
83.21	4.27	83.59	4.28	0.38	1.58	0.332 NS	0.000***
51.76	6.94	52.65	7.41	0.88	2.28	0.130 NS	0.002**
48.03	7.30	48.56	8.01	0.53	2.52	0.398 NS	0.664 NS
−3.35	1.52	−3.05	1.90	0.31	0.80	0.131 NS	0.242 NS
−0.53	2.33	−0.22	2.09	0.31	0.62	0.053 NS	0.243 NS
30.53	2.65	34.03	2.73	3.50	1.00	0.000***	0.000***
61.53	3.56	66.47	3.24	4.94	1.75	0.000***	0.000***
34.23	2.57	40.29	4.38	6.06	2.45	0.000***	0.006**
45.01	2.35	51.78	3.07	6.77	2.02	0.000***	0.000***

fabricate. Occasional failure in delivery may result from inaccurate band placement before the pouring and soldering steps. However, the acrylic-bonded fully tooth- and tissue-borne expander is easily fabricated and does not require orthodontic bands. All acrylic appliances have the potential for palatal mucosa ulceration. We did not report any unusual symptoms such as pain or dizziness in any of the patients. When we removed the appliance, we noticed hyperemia on the palatal mucosa and gums in all patients; however, it disappeared spontaneously in few days soon after appliance removal.

A significant percentage of transverse maxillary deficiency cases have anterior rather than posterior transverse narrowness. In these cases, expansion should be achieved in the intercanine area without expanding the intermolar region, in order not to create posterior buccal crossbites that are hard to correct. For a correct approach to the resolution of such cases, we consider a thorough knowledge of the mechanism of the expansion device to be appropriate.

The fan-type RME, Ragno, generates differential expansion of the transverse diameters of the arch. Studies to date have shown that RME appliances separate the midpalatal suture greatest anteriorly rather than posteriorly. However, the interarch changes did not mimic the sutural separation pattern because the intermolar changes were dimensionally greater than the intercanine changes.[3,12,14,20] The fan-type Ragno screw permits a more rational management of expansion by differentiating between the treatments of the anterior and posterior diameters. A fan-type appliance is effective in expanding the anterior rather than the posterior part of the upper arch.[15–17] However, does this screw have a skeletal effect or does it create only dental expansion without affecting the facial structures? The principal goal of this study was to determine the effects of the fan-type RME and to compare them with those of the more conventional RME.

Biomechanics

Biederman[18] explained the angular displacement of maxilla in the horizontal plane in two ways (Figure 8). In the schematic diagram, semicircle represents the halves of the maxilla, and the rectangle represents the bony complex with which it articulates posteriorly. The tangent to the semicircle defines point A at the point of tangency (Figure 8A). He concluded that if the center of rotation be any where in the midline, lateral points B and C must move backward, which entail the resorption of bone (the shaded area). He also noted that point A would also move slightly backward (Figure 8B). However, he found this consequence was unlikely to occur in so short a time as two weeks. His second theory was that the angular displacement must occur with centers of rotation at B and C, which results in the advance of point A (Figure 8C).

We also have three proposed hypotheses of the biomechanics of fan-type rapid expansion in the horizontal plane using a schematic diagram similar to that of Biederman (Figure 9). In the first theory, although the appliance, as designed, tries to alter the force system affecting intermolar region, the posterior part of the midpalatal suture must open

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TABLE 3. Changes and Comparisons of Posttreatment and Postretention Values Between and Within the Groups

		Group I						
		Posttreatment (T2)		Postretention (T3)		Difference (T3 − T2)		
		Mean	SD	Mean	SD	Mean	SD	Paired *t*-test
1	SNA (°)	80.47	2.67	79.71	2.64	−0.76	0.44	0.000***
2	SNB (°)	75.23	2.11	75.47	2.12	0.24	0.56	0.104 NS[a]
3	ANB (°)	5.29	2.26	4.29	2.11	−1.00	0.61	0.000***
4	SN-MP (°)	39.29	5.43	38.35	5.45	−0.94	0.75	0.000***
5	SN-PP (°)	9.88	2.23	9.59	2.00	−0.29	0.59	0.056 NS
6	MP-PP (°)	29.59	4.80	29.00	4.70	−0.59	1.12	0.046*
7	SV⊥A (mm)	58.71	4.16	57.94	4.13	−0.76	0.66	0.000***
8	SV⊥B (mm)	42.71	5.10	43.18	5.05	0.47	0.87	0.041*
9	N-ANS (mm)	56.00	3.16	55.71	3.16	−0.29	0.47	0.020*
10	ANS-Me (mm)	66.29	3.67	65.82	3.80	−0.47	1.07	0.088 NS
11	U1P-SN (°)	104.29	6.35	104.08	6.13	−0.21	1.40	0.055 NS
12	L1P-MP (°)	91.06	5.91	90.71	5.67	−0.35	2.03	0.484 NS
13	SN⊥U1 (mm)	84.71	3.50	84.12	3.44	−0.59	0.80	0.008**
14	SV⊥U1 (mm)	59.53	5.70	58.94	5.58	−0.59	0.80	0.008**
15	SV⊥L1 (mm)	52.82	4.17	53.12	3.94	0.29	0.85	0.172 NS
16	UL-E (mm)	−1.59	1.62	−1.47	2.00	0.12	0.93	0.608 NS
17	LL-E (mm)	−1.94	1.68	−1.53	1.55	0.41	0.94	0.090 NS
18	NC-CN (mm)	36.82	1.98	36.35	2.09	−0.47	0.51	0.002**
19	JL-JR (mm)	60.58	1.90	60.47	1.84	−0.12	0.33	0.163 NS
20	Upper intercanine width (mm)	41.06	2.66	39.12	2.18	−1.94	1.09	0.000***
21	Upper intermolar width (mm)	48.41	2.21	47.65	2.21	−0.76	0.56	0.000***

[a] NS indicates nonsignificant.
* $P < .05$, ** $P < .01$, *** $P < .001$.

TABLE 4. Changes and Comparisons of Pretreatment and Postretention Values Between and Within the Groups

		Group I						
		Pretreatment (T1)		Postretention (T3)		Difference (T3 − T1)		
		Mean	SD	Mean	SD	Mean	SD	Paired *t*-test
1	SNA (°)	78.35	2.89	79.71	2.64	1.35	0.61	0.000***
2	SNB (°)	75.76	2.28	75.47	2.12	−0.29	0.69	0.096 NS
3	ANB (°)	2.59	2.79	4.29	2.11	1.71	1.10	0.000***
4	SN-MP (°)	37.53	5.39	38.35	5.45	0.82	1.13	0.008**
5	SN-PP (°)	8.94	1.92	9.59	2.00	0.65	0.70	0.002**
6	MP-PP (°)	27.35	7.96	29.00	4.70	1.65	4.62	0.161 NS
7	SV⊥A (mm)	56.41	3.99	57.94	4.13	1.53	0.72	0.000***
8	SV⊥B (mm)	43.00	5.12	43.18	5.05	0.18	1.42	0.616 NS
9	N-ANS (mm)	54.59	3.12	55.71	3.16	1.12	1.17	0.001**
10	ANS-Me (mm)	65.24	3.51	65.82	3.80	0.59	1.23	0.066 NS
11	U1P-SN (°)	100.18	6.90	104.08	6.13	3.28	2.21	0.000***
12	L1P-MP (°)	90.94	6.00	90.71	5.67	−0.24	1.86	0.608 NS
13	SN⊥U1 (mm)	82.65	3.59	84.12	3.44	1.47	0.87	0.000***
14	SV⊥U1 (mm)	56.35	6.33	58.94	5.58	2.59	1.33	0.000***
15	SV⊥L1 (mm)	52.59	3.76	53.12	3.94	0.53	0.72	0.008**
16	UL-E (mm)	−2.41	2.65	−1.47	2.00	0.94	1.09	0.003**
17	LL-E (mm)	−1.82	1.88	−1.53	1.55	0.29	1.31	0.369 NS
18	NC-CN (mm)	34.41	1.91	36.35	2.09	1.94	0.56	0.000***
19	JL-JR (mm)	60.18	1.74	60.47	1.84	0.29	0.47	0.020*
20	Upper intercanine width (mm)	32.94	2.28	39.12	2.18	6.18	1.19	0.000***
21	Upper intermolar width (mm)	45.76	2.28	47.65	2.21	1.88	0.60	0.000***

[a] NS indicates nonsignificant.
* $P < .05$, ** $P < .01$, *** $P < .001$.

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TABLE 3. Extended

Group II							
Pretreatment (T2)		Posttretention (T3)		Difference (T3 − T2)			
Mean	SD	Mean	SD	Mean	SD	Paired *t*-test	Student's *t*-test
79.53	3.15	79.41	3.11	−0.12	0.55	0.387 NS	0.000***
75.29	2.87	75.53	2.88	0.24	0.50	0.072 NS	1.000 NS
4.24	1.97	3.88	1.95	−0.35	0.39	0.002**	0.000***
40.94	7.17	40.50	7.18	−0.44	0.46	0.001**	0.025*
8.94	2.34	9.21	2.38	0.26	1.08	0.326 NS	0.069 NS
30.71	6.60	30.68	6.49	−0.03	0.41	0.773 NS	0.063 NS
52.56	6.56	52.32	6.29	−0.24	0.73	0.203 NS	0.034*
37.18	10.04	37.71	9.83	0.53	0.67	0.005**	0.827 NS
56.62	3.44	56.32	3.36	−0.29	1.00	0.243 NS	1.000 NS
71.15	5.56	70.65	5.37	−0.50	1.13	0.087 NS	0.938 NS
102.50	6.07	102.61	6.07	0.11	1.62	0.311 NS	0.052 NS
89.56	5.00	89.41	4.61	−0.15	1.53	0.697 NS	0.740 NS
83.59	4.28	83.71	4.32	0.12	1.22	0.696 NS	0.054 NS
52.65	7.41	52.53	7.26	−0.12	0.72	0.509 NS	0.079 NS
48.56	8.01	48.62	7.78	0.06	0.93	0.798 NS	0.447 NS
−3.05	1.90	−3.06	1.58	0.01	0.93	0.959 NS	0.680 NS
−0.22	2.09	−0.35	2.40	−0.14	0.59	0.350 NS	0.051 NS
34.03	2.73	33.88	2.53	−0.15	0.29	0.056 NS	0.032*
66.47	3.24	66.39	3.24	−0.08	0.18	0.091 NS	0.654 NS
40.29	4.38	40.14	4.42	−0.16	0.33	0.065 NS	0.000***
51.78	3.07	51.68	3.08	−0.09	0.20	0.076 NS	0.000***

slightly. This angular opening may occur with centers of rotation at points B and C. This opening is more V shaped than with the RME. This means that the displacement is mostly rotational and with a minimally parallel response (Figure 9A).

In the second theory, the effect of the mechanism of the appliance inhibits the separation of the whole midpalatal suture. The center of angular opening is anywhere in the midline that is distal to the hinge point (point X). However, the maxilla again rotates on points B and C in addition to

TABLE 4. Extended

Group II							
Pretreatment (T1)		Postretention (T3)		Difference (T3 − T1)			
Mean	SD	Mean	SD	Mean	SD	Paired *t*-test	Student's *t*-test
78.09	3.70	79.41	3.11	1.32	1.13	0.000***	0.925 NS
76.03	2.91	75.53	2.88	−0.50	0.85	0.027*	0.442 NS
2.06	2.32	3.88	1.95	1.82	1.13	0.000***	0.761 NS
39.09	7.26	40.50	7.18	1.41	1.03	0.000***	0.123 NS
9.65	2.66	9.21	2.38	−0.44	1.66	0.289 NS	0.018*
29.50	6.52	30.68	6.49	1.18	1.40	0.003**	0.690 NS
50.91	6.54	52.32	6.29	1.41	1.73	0.004**	0.796 NS
38.26	9.58	37.71	9.83	−0.56	1.26	0.086 NS	0.121 NS
55.32	3.25	56.32	3.36	1.00	1.75	0.032*	0.819 NS
68.56	4.63	70.65	5.37	2.09	2.22	0.001**	0.021*
103.71	7.28	102.61	6.07	−1.10	2.96	0.286 NS	0.000***
89.71	4.47	89.41	4.61	−0.29	2.33	0.610 NS	0.935 NS
83.21	4.27	83.71	4.32	0.50	1.33	0.142 NS	0.017*
51.76	6.94	52.53	7.26	0.76	1.76	0.092 NS	0.002**
48.03	7.30	48.62	7.78	0.59	1.95	0.231 NS	0.908 NS
−3.35	1.52	−3.06	1.58	0.29	0.66	0.086 NS	0.044*
−0.53	2.33	−0.35	2.40	0.18	0.43	0.111 NS	0.728 NS
30.53	2.65	33.88	2.53	3.35	0.90	0.000***	0.000***
61.53	3.56	66.39	3.24	4.86	1.64	0.000***	0.000***
34.23	2.57	40.14	4.42	5.91	2.55	0.000***	0.069 NS
45.01	2.35	51.68	3.08	6.68	1.99	0.000***	0.000***

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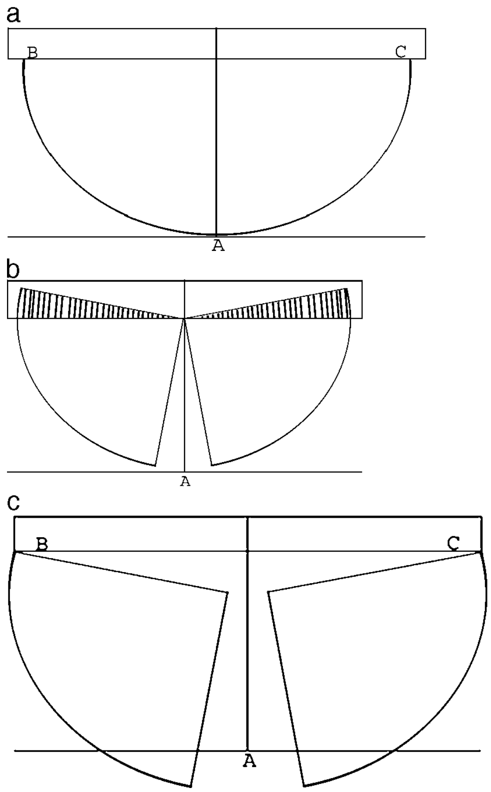

FIGURE 8. Schematic diagram showing possible anteroposterior movement with RME. (A) The semicircle represents the right and left parts of maxilla, and the rectangle represents the bones articulating with them posteriorly. Point A is the point of tangency to the semicircle at midline. (B) If the center of angular opening is anywhere in the midline, point A moves slightly backward and the two lateral points B and C even more, implying extensive bone resorption (the shaded area). (C) If the angular opening is due to two centers of rotation at B and rotation at B and C, respectively, point A advances.

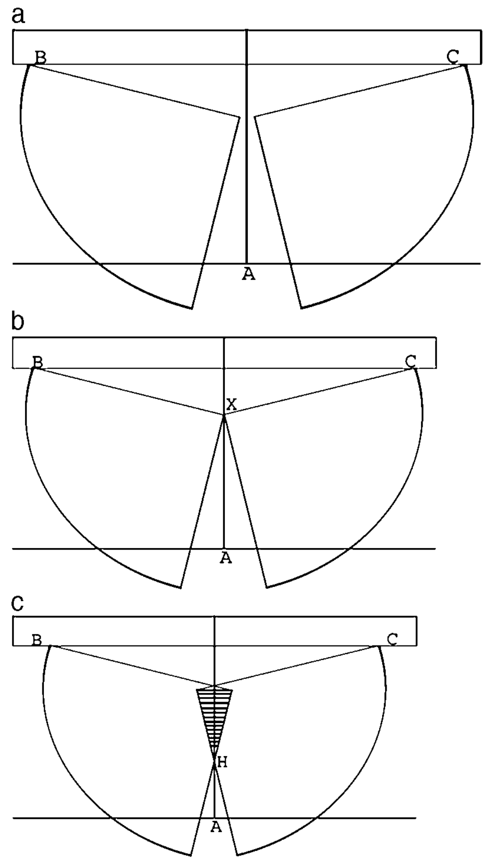

FIGURE 9. Schematic diagram showing possible anteroposterior movement with fan-type RME. (A) The midpalatal suture separates, however, in a more V shape than RME. Compare with Figure 8C. (B) The construction of the appliance does not permit the opening of whole midpalatal suture. The angular opening is due to three centers of rotation at B, C, and X that is in the midline distal to the hinge point. (C) The center of angular opening is on the hinge point. A contraction must occur in the part of maxilla that is distal to the hinge point due to the effect mechanism of fan-type RME. Maxilla rotates on points B, C, and H.

point X and consequently point A advances (Figure 9B). The third theory is a resorption theory. The point of opening was moved to the hinge point because of the effect of the mechanism of the fan-type appliance. A contraction must occur in the part of maxilla that is distal to the hinge point, and this would entail the resorption of posterior maxillary bone (the shaded area) (Figure 9C). However, this consequence was not likely to occur in so short a time as three weeks. Although one of the center of rotation was in the midline (point H), the lateral points B and C could not move backward as previously mentioned by Biederman, when point A moved forward in all patients in our study group. That means an angular opening may occur with centers of rotation at points B, C, and H.

Lateral cephalometric evaluations

While considering the position of the maxilla sagittally, we observed that the SNA and SV ⊥ A distance increased significantly in both groups. Although a significant reduction in SNA and SV ⊥ A distance was noted during retention in group I, a statistically significant increase was found at the end of the retention in both groups. Many investigators have reported that the maxilla moves forward and downward with the use of different RME appliances.[3,11,12,14,18,21–24] Our findings show that fan-type RME also forces the maxilla forward more than the RME. This means the fan-type RMEs also have a buttressing effect on the skeletal structures behind the maxilla because of the rotational opening.

Many investigators have reported that an RME results in a downward movement of the maxilla, more at ANS than at PNS, which creates an increase in the palatal plane angle and upper face dimensions.[3,11,12,14,21,25–27] In our study, we also noted that the values of N-ANS were increased in both groups. We observed that fan-type RME also moves maxilla downward just as the RME.

The decrease in SNB angle was significant in group II and nonsignificant in group I, reflecting the downward ro-

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tation of the mandible, which could be the result of the downward movement of the maxilla. Although the decrease in group II was greater than in group I, there was no statistical difference between the groups at the end of the retention.

The ANB angle increased significantly in both groups because of a combination forward movement of point A and the backward rotation of the mandible. Sarver and Johnston,[28] Haas,[3,25] and Wertz[14] found that SNA and ANB increase after RME treatment, similar to our findings.

When considering the mandibular position vertically, the SN-MP angle increased significantly in both groups but more in group II. This difference between the groups was statistically significant. Also ANS-Me increased in group II; however, there was no change in group I. Our findings indicate that vertical dimension control was better with the fan-type RME than with the RME. Northway and Meade[29] evaluated the different expansion modalities and concluded that none of them resulted in appreciable buccal flaring or tipping. Extrusion of the maxillary posterior teeth or a downward displacement of the maxilla has been suggested as a possible mechanism that leads to clockwise mandibular rotation. In anterior maxillary restricted cases, the fan-type RME increases the intercanine width without increasing the intermolar width so the molars would not tip. Thus, the vertical dimension could be better controlled in group I.

In our study, a palatal movement of the maxillary incisors was noted in group II, in agreement with previous reports.[14,28,30] However, in group I, the buccal tipping of the maxillary incisors differed from previous studies. Because the angular opening of the midpalatal suture with the fan-type RME is more rotational than with the RME, the anterior teeth were moved laterally and anteriorly with the fan-type RME, whereas they were uprighted with the RME.

Frontal cephalometric evaluations

Studies to date have shown the RME to be associated with various degrees of increase in the nasal cavity dimension and a decrease in nasal obstruction.[11,14,21,24,25,31,32] Derichsweiler[7] reported that suture opening allowed many mouth breathers to adapt to the use of the nasal passages for respiration. Group II presented with significantly greater increments for both nasal cavity width and maxillary width when compared with group I.

The difference in maxillary width changes between the two groups was not surprising. The design of the fan-type RME screw limited expansion in the posterior region of the maxilla, so a slight expansion of maxillary width in group I was an expected result. We had expected to observe increments of nasal cavity width increase in group I at least similar to those in group II. However, group II presented with significantly greater increments of nasal cavity width increase. All RME appliances in use today push below the center of resistance as viewed from the frontal plane. We hypothesized that fan-type RME appliance required a lower orthopedic force range than the RME appliance. Therefore, the center of rotation may be as high as the frontomaxillary suture with the RME and somewhere within nasal airway or below in the fan-type RME. We concluded that the fan-type RME appears to induce expansion at a more at dentoalveoler level; however, the RME was associated with significant widening of the maxilla at a skeletal level.

Intercanine and intermolar width evaluations

There was no difference between the groups in intercanine width; however, group II presented with significantly greater increments for the final intermolar width at the end of the retention period. Timms,[33] Haas,[3] Bell and LeCompte,[20] Wertz,[14] and Adkins et al[30] all observed that the ratio of intercanine-intermolar width is nearly 50%. However, results from this study show that the ratio between the intercanine width and intermolar widths was nearly 3:1 in group I. This is a great difference and reproducible as long as a device opens in a V shape, causing more expansion in the anterior part of the maxilla. A fan-type RME can expand the maxillary arch more anteriorly rather than posteriorly. These findings may be of a great benefit in the treatment of certain patients exhibiting anterior maxillary narrowness with normal intermolar width.

CONCLUSIONS

The fan-type RME appliance separated the midpalatal suture like the conventional RME appliances. In addition, the action of the appliances showed more results:

- Intermolar width showed a slight expansion with fan-type RME when compared with the conventional RME.
- There were no differences for intercanine width between the groups.
- Opening of the midpalatal suture is more parallel in RME than in fan-type RME when viewed from the coronal and frontal plane.
- The changes achieved in dentofacial structures with a conventional RME were more stable than that achieved with the fan-type RME.
- The maxilla moved downward and forward in both groups.
- Both groups I and II demonstrated significant increase in vertical dimension. However, the fan-type RME avoided expanding and tipping the posterior teeth, which causes increase in vertical facial height.
- The upper incisors were tipped palatally in group II and tipped buccally in group I.
- Nasal cavity width increased more in group II than in group I.

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REFERENCES

1. Greenbaum KR, Zacrisson BU. The effect of palatal expansion therapy on the periodontal supporting tissues. *Am J Orthod.* 1982; 81:12–21.
2. Angell EC. Treatment of irregularities of the permanent or adult teeth. *Den Cosmos* 1860;1:540–544.
3. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the mid palatal suture. *Angle Orthod.* 1961;31: 73–90.
4. Isaacson RJ, Wood JL, Ingram AH. Forces produced by rapid maxillary expansion. I and II. *Angle Orthod.* 1964;34:256–270.
5. Biederman W. An hygienic appliance for rapid expansion. *J Pract Orthod.* 1968;2:67–70.
6. Isaacson RJ, Murphy TD. Some effects of rapid maxillary expansion on cleft lip and palate patients. *Angle Orthod.* 1964;34: 143–154.
7. Derichsweiler H. *Gaumennahterweiterweiterung.* München: Carl Hanser Verlag; 1956.
8. Alpern MC, Yurosko JJ. Rapid palatal expansion in adults with and without surgery. *Angle Orthod.* 1987;57:245–263.
9. Majourau A, Nanda R. Biomechanical basis of vertical dimension control during rapid palatal expansion therapy. *Am J Orthod Dentofacial Orthop.* 1994;106:322–328.
10. Subtelny JD. Oral respiration, facial maldevelopment and corrective dentofacial orthopedics. *Angle Orthod.* 1980;50:147–164.
11. Wertz RA, Dreskin M. Midpalatal suture opening: a normative study. *Am J Orthod.* 1977;71:367–381.
12. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. *Am J Orthod.* 1970;57:219–255.
13. Spolyar JL. The design, fabrication, and use of a full-coverage bonded rapid maxillary expansion appliance. *Am J Orthod.* 1984; 86:136–145.
14. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. *Am J Orthod.* 1970;58:41–66.
15. Schellino E, Modica R, Benech A, Modaro E. REM: la vite ragno secondo Schellino e Modica. *Boll Interm Orthod. Leone* 1996;55: 36–39.
16. Levrini L, Filippi V. A fan shaped maxillary expander. *J Clin Orthod.* 1999;33:642–643.
17. Sadeddin A. *Cephalometric Evaluation of Anterior Maxillary Expansion* [master's thesis]. Istanbul: Marmara University Health Sciences Institute; 2000.
18. Biederman W. Rapid correction of class III malocclusion by midpalatal expansion. *Am J Orthod.* 1973;63:47–55.
19. Sokal RR, Rohlf FS. *Biometry.* San Francisco, Calif: WH Freeman Company; 1981.
20. Bell RA, LeCompte EJ. The effects of maxillary expansion using a quadhelix appliance during the deciduous and mixed dentitions. *Am J Orthod.* 1981;79:152–161.
21. Haas AJ. Long-term post treatment evaluation of rapid palatal expansion. *Angle Orthod.* 1980;50:189–217.
22. Erverdi N, Sabri A, Küçükkeleş N. Cephalometric evaluation of Haas and hyrax rapid maxillary appliances in the treatment of the skeletal maxillary transverse deficiency. *J Marmara Univ. Dent Faculty* 1993;1:361–366.
23. Timms DJ. *Rapid Maxillary Expansion.* Chicago, Ill: Quintessence Publishing Co Inc; 1981.
24. Başçiftçi FA, Karaman AI. Effects of a modified acrylic bonded rapid maxillary expansion appliance and vertical chin cap on dentofacial structures. *Angle Orthod.* 2002;72:61–71.
25. Haas AJ. The treatment of maxillary deficiency by opening mid palatal suture. *Angle Orthod.* 1965;35:200–217.
26. Byrum AG. Evaluation of anterior-posterior and vertical skeletal changes in rapid palatal expansion cases as studied by lateral cephalograms. *Am J Orthod.* 1971;60:419.
27. Reed N, Ghosh J, Nanda RS. Comparison of treatment outcomes with banded and bonded RPE appliances. *Am J Orthod Dentofacial Orthop.* 1999;116:31–40.
28. Sarver DM, Johnston MW. Skeletal changes in vertical and anterior displacement of the maxilla with bonded rapid palatal expansion appliances. *Am J Orthod Dentofacial Orthop.* 1989;95: 462–466.
29. Northway WM, Meade JB Jr. Surgically assisted rapid maxillary expansion: A comparison of technique, response and stability. *Angle Orthod.* 1997;67:309–320.
30. Adkins MD, Nanda RS, Currier GF. Arch perimeter changes on rapid palatal expansion. *Am J Orthod Dentofacial Orthop.* 1990; 97:194–199.
31. Warren DW, Hershey HG, Turvey TA, et al. The nasal airway following maxillary expansion. *Am J Orthod Dentofacial Orthop.* 1987;91:111–116.
32. Basciftci FA, Mutlu N, Karaman AI, Malkoc S, Kucukkolbasi H. Does the timing and method of rapid maxillary expansion have an effect on the changes in nasal dimensions? *Angle Orthod.* 2002;72:118–123.
33. Timms DJ. A study of basal movement with rapid maxillary expansion. *Am J Orthod.* 1980;77:500–507.

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