Original Article

Dentofacial changes from fan-type rapid maxillary expansion vs traditional rapid maxillary expansion in early mixed dentition

A prospective clinical trial

Bayram Çörekçi[a]; Yasar B. Göyenç[b]

ABSTRACT

Objective: To test the null hypothesis that there is no difference between the effects of fan-type rapid (FRME) and rapid maxillary expansion (RME) used with an acrylic bonded expansion appliance on dentofacial structures in early occlusal stages.

Materials and Methods: This was a prospective clinical trial. The FRME group had an anterior constricted maxillary width with a normal intermolar width, and the RME group had bilateral constricted maxillary width. The FRME group consisted of 20 patients (mean age, 8.96 ± 1.19 years), and the RME group consisted of 22 patients (mean age, 8.69 ± 0.66 years). Lateral and frontal cephalometric radiographs and dental casts were taken before and after expansion and 3 months after completing treatment for each patient. The data were compared using repeated-measures analysis of variance. The paired-samples *t*-test was used to evaluate treatment and retention effects, and the independent samples *t*-test was used to consider the differences between the two groups.

Results: The maxilla moved downward and forward in both groups. The nasal cavity and maxillary width were expanded more in the RME group, and there were only a few relapses in this group during the retention period. There was significant labial tipping of the upper incisors in the FRME expansion group. The expansion of intercanine width was similar in both groups, but the expansion of intermolar width was significantly greater in the RME group.

Conclusion: The null hypothesis was rejected. There was a difference between the effects of FRME and RME used with an acrylic bonded expansion appliance on dentofacial structures in the early occlusal stages. (*Angle Orthod.* 2013;83:842–850.)

KEY WORDS: Fan-type palatal expansion; Rapid maxillary expansion; Mixed dentition

INTRODUCTION

A lateral crossbite may be seen during all periods of dentition and is characterized by a narrowing of the transverse dimension of the maxillary arch.[1] In the literature, many contemporary concepts of transverse deficiency have been fully described, with most investigations claiming that lateral crossbite cannot be corrected by time or that there is no self-correction ability with this anomaly.[2–5] Moreover, previous researchers[1–6] have suggested that this form of malocclusion must be treated when first observed, for example, in the deciduous or mixed dentition.

A transverse deficiency, which is the most frequently observed transverse malocclusion,[6] may be successfully corrected using rapid maxillary expansion (RME). With RME procedures, there are some criteria that must be handled according to the requirements: these include the rate of screw activation, produced force level, treatment time, and the age of patients.[3,7–9] Furthermore, nowadays, many orthodontists prefer screws in banded or bonded appliances with some modifications for the expansion of dental or skeletal constriction in early dental ages.

Narrowing of the intercanine width with no posterior constriction may be encountered in routine practice, and this will be problematic when using traditional RME. This problem can be resolved by utilizing a screw that has the ability to add more expansion in that

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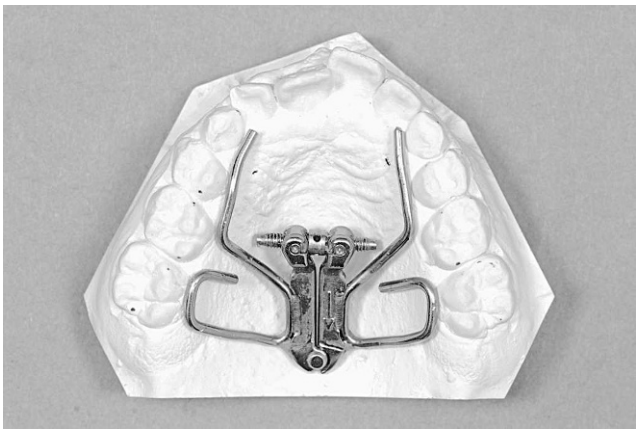

Figure 1. Ragno screw on dental cast after bending.

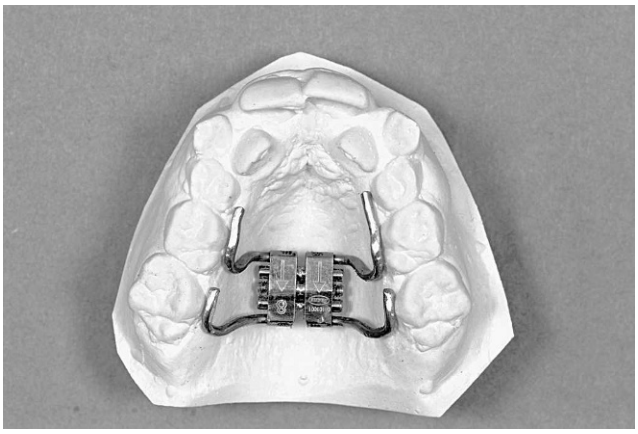

Figure 2. Hyrax screw on dental cast after bending.

area. Two investigations[10,11] used a "Ragno" screw, which is designed to work asymmetrically and allows "fan opening." Doruk et al.[10] used this screw in an acrylic bonded RME appliance called the fan-type RME (FRME) to produce expansion in only the intercanine region of the maxilla. In their study, there was no expansion of intermolar width; furthermore, their results provided an advantage for the future treatment of such cases.

While the outcomes of RME protocols in the primary and mixed dentitions are defined in the literature,[1,3,4,9] there has been no published information on the outcome of the FRME procedure in early occlusal stages. Therefore, the purpose of this prospective study was to evaluate and compare the effects of FRME and conventional RME in a modified acrylic bonded expansion appliance on dentofacial structures for the treatment of transverse deficiency in the mixed dentition period. The null hypothesis was that no difference would be found between the effects of the two maxillary expansion methods on dentofacial structures in the mixed dentition.

Table 1. Definition of Measurements[a]

1	SNA, °	Angle formed by the planes of sella-nasion (SN) and nasion–point A
2	SNB, °	Angle formed by the planes of SN and nasion–point B
3	ANB, °	Angle formed by the planes of nasion–point A and nasion–point B
4	SN-PP, °	Angle formed by the SN plane and the palatal plane (PP) (anterior nasal spine [ANS]–posterior nasal spine [PNS])
5	MP-PP, °	Angle formed by the mandibular plane (MP) (gonion-menton) and the PP
6	SN-MP, °	Angle formed by the SN and MP
7	N-ANS, mm	The distance between N and ANS
8	ANS-Me, mm	The distance between ANS and menton
9	SN⊥ANS, mm	The perpendicular distance of ANS to SN
10	SN⊥PNS, mm	The perpendicular distance of PNS to SN
11	SV⊥A, mm	The perpendicular distance of point A to the sella vertical plane (SV) was constructed through the sella, perpendicular to the sella-nasion plane
12	SV⊥B, mm	The perpendicular distance of point B to SV
13	SN-U1P, °	Angle formed between SN and upper central incisor plane (U1P) (a plane from the upper central incisor's incisal edge through its root)
14	SV⊥U1, mm	The perpendicular distance of the incisal edge of upper central incisor to SN
15	L1P-MP, °	Angle formed between MP and lower central incisor plane (L1P) (a plane from the lower central incisor's incisal edge through its root)
16	SV⊥L1, mm	The perpendicular distance of incisal edge of lower central incisor to SV
17	UL-E, mm	The perpendicular distance of the most anterior point on the convexity of the upper lip to E plane that extends from the tip of the nose and the chin
18	LL-E, mm	The perpendicular distance of the most anterior point on the convexity of lower lip to the E plane
19	NC-CN, mm	Nasal cavity width, the distance between left and right lateral piriform rims
20	JL-JR, mm	Maxillary skeletal width, the distance between left and right jugale points
21	UC-UC, mm	The width between the upper canines
22	UM-UM, mm	The width between the upper first molars
23	LC-LC, mm	The width between the lower canines
24	LM-LM, mm	The width between the lower first molars

[a] 1–18 = lateral cephalograms; 19 and 20 = frontal cephalograms; 21–24 = dental casts.

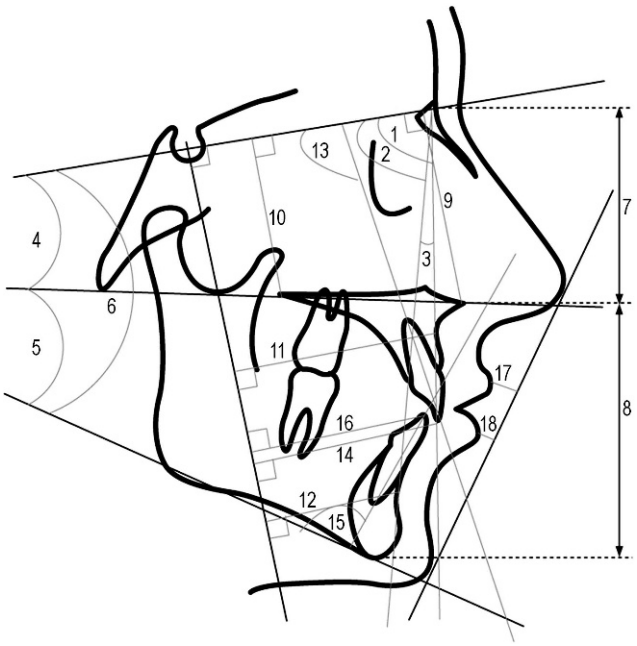

Figure 3. Lateral cephalometric measurements.

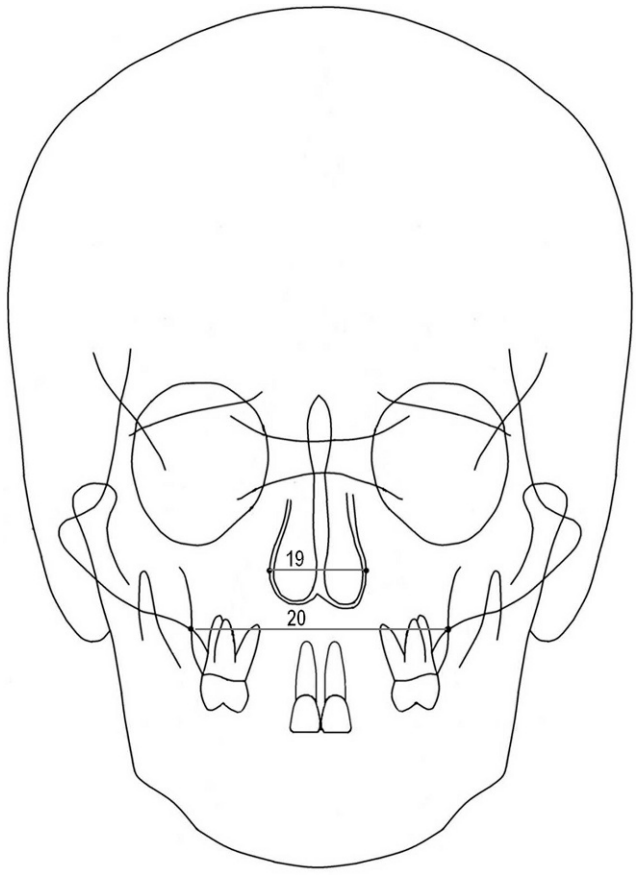

Figure 4. Frontal cephalometric measurements.

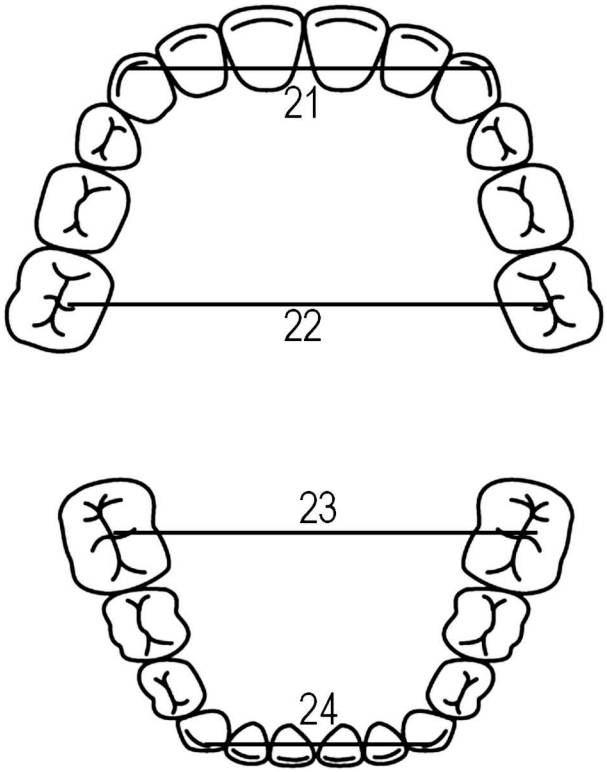

Figure 5. Dental cast measurements.

MATERIALS AND METHODS

The sample involved 50 consecutive patients (24 female and 26 male) who were treated at the Department of Orthodontics at Selçuk University (Konya, Turkey). Eight subjects were excluded from the study because of cooperation and record problems as well as repeated appliance failure and extra-long activation time. Patients were treated under the ethical regulations for human experiments, as explained by the research ethics committee of the Dentistry Faculty of Selçuk University, and they completed a written informed consent form. The FRME group (n = 20 patients) included nine girls and 11 boys (mean age, 8.96 ± 1.1 years; range, 7.5–10.3 years) diagnosed with an anteriorly constricted maxillary arch (V shaped) and with normal intermolar width. The RME group (n = 22 patients) included 11 girls and 11 boys (mean age, 8.69 ± 0.7 years; range, 7.8–10.2 years) diagnosed with a posteriorly constricted maxillary arch and with posterior crossbite.

Patients met the following inclusion criteria: (1) no systemic diseases; (2) no history of orthodontic treatment; (3) no pathologic periodontal status; (4) mixed dentition; and (5) erupted first permanent molars.

A splint-type tooth and tissue-borne RME appliance were used in both groups.[4,9,10] In the FRME group, the Hinge of Ragno (Leone, Firenze, Italy) was placed tangentially to the distal point of the permanent molars

according to the method of Doruk et al.[10] (Figure 1). In the RME group, a hyrax (Leone, Firenze, Italy) positioned parallel to the second deciduous molars (Figure 2).[4,9] The screws were activated twice a day (0.25 mm per turn, 0.5 mm daily) in the first week to overcome the resistance of the sutures and then once a day after suture opening. Suture opening was confirmed through the occlusal radiograms. The 2–4-mm overcorrection of dental crossbite was intended to compensate for relapse. After expansion, the screws were fixed for 2 weeks to minimize discomfort during removal. Then a removable retention appliance (Hawley plate) was used passively. The mean treatment and retention times were 19.7 $\pm$ 2.0 days and 91.5 $\pm$ 4.1 days, respectively, for the FRME group and 22.8 $\pm$ 2.5 days and 93.2 $\pm$ 4.1 days, respectively, for the RME group.

Lateral and frontal cephalometric radiographs and dental casts were taken before expansion (T1) and after expansion (T2) and 3 months after treatment completion (T3) for each patient. The landmarks and measurements used are defined in Table 1 and shown in Figures 3 through 5.

Approximately 1 month later, 126 records from each group were randomly selected and remeasured by the same author. The method error was calculated using Dahlberg's formula ($\sqrt{\Sigma d^2/2n}$).

A descriptive analysis was obtained. Analysis of variance (ANOVA) was used to test for the homogeneity of groups. Repeated-measures ANOVA was utilized to determine the measurement differences between different time points for each group. If there were any statistical differences, the paired-samples *t*-test was used. The independent samples *t*-test was applied for comparison of the groups. All analyses were performed using SPSS (SPSS Inc, Chicago, IL, USA).

RESULTS

The beginning values of both groups were shown to have homogeneous distribution according to ANOVA. The lowest method error was in LM-LM (0.25 mm), while the highest was at the SN-U1P angle, 0.71°. T1, T2, and T3 measurements and comparisons are presented in Tables 2 and 3.

Pretreatment vs Posttreatment

In the FRME group, treatment was associated with significant increases in SNA and ANB angles; N-ANS, SN $\perp$ ANS, SN $\perp$ PNS, SV $\perp$ A, and SV $\perp$ U1 distances ($P < .001$); and SN-MP and SN-U1P angles ($P < .05$).

In the RME group, treatment was associated with significant increases in SNA and ANB angles; SN $\perp$ ANS, SN $\perp$ PNS, and SV $\perp$ U1 distances ($P < .001$); N-ANS and SN $\perp$ ANS distances ($P < .01$); and MP-PP and SN-MP angles ($P < .05$). The increase in the SN-U1P angle was significantly greater in the FRME group ($P < .05$).

In both groups, treatment was associated with significant increases NC-CN and JL-JR distances ($P < .001$). The increases in the NC-CN and JL-JR distances were significantly greater in the RME group ($P < .01$).

In both groups, treatment was associated with significant increases in UC-UC and UM-UM distances ($P < .001$). LC-LC distance was significantly increased in the RME group ($P < .01$). The increase in UM-UM distance was significantly greater in the RME group ($P < .001$).

Pretreatment vs Postretention

In the FRME group, treatment and retention were associated with significant increases in SNA and ANB angles; N-ANS and SN $\perp$ PNS distances ($P < .001$); SN-MP angle; and SN $\perp$ ANS distance ($P < .05$). In the RME group, treatment and retention were associated with significant increases in SN $\perp$ PNS distance ($P < .001$); N-ANS distance ($P < .01$); SNA, ANB, MP-PP, and SN-MP angles; and ANS-Me, SN $\perp$ ANS, and SV $\perp$ U1 distances ($P < .05$). The increases in SNA and ANB angles were significantly greater in the FRME group ($P < .05$ and $P < .001$, respectively).

In the RME group, treatment and retention were associated with significant increases in NC-CN and JL-JR distances ($P < .001$). The increases in NC-CN and JL-JR distances were significantly greater in the RME group ($P < .01$).

In both groups, treatment and retention were associated with significant increases in UC-UC and UM-UM distances ($P < .001$). LC-LC distance significantly increased in the RME group ($P < .05$). The increase in UM-UM distance was significantly greater in the RME group ($P < .001$).

Posttreatment vs Postretention

In the FRME group, retention was associated with a significant increase in SN $\perp$ PNS distance ($P < .05$), whereas SN $\perp$ ANS, SV $\perp$ A, and SV $\perp$ U1 distances were decreased ($P < .05$). In the RME group, retention was associated with a significant increase in ANB angle ($P < .05$), whereas SNA angle and SN $\perp$ A distance were decreased ($P < .05$). The increase in ANB angle was significantly greater in the FRME group ($P < .01$).

In the FRME group, retention was associated with a significant decrease in NC-CN distance ($P < .01$). In the RME group, retention was associated with significant decreases in NC-CN and JL-JR distances

Table 2. Changes and Comparisons of Pretreatment, Posttreatment, and Postretention Values Within the Groups[a]

		FRME Group						
		T1 Mean ± SD	T2 Mean ± SD	T3 Mean ± SD	RM-ANOVA	T1-T2	T1-T3	T2-T3
Lateral cephalometric measurements								
1	SNA	77.37 ± 3.49	79.05 ± 3.53	78.67 ± 3.54	***	***	***	
2	SNB	74.84 ± 3.24	75.13 ± 3.47	74.69 ± 3.56	ns			
3	ANB	2.52 ± 1.58	3.92 ± 1.82	3.97 ± 1.82	***	***	***	
4	SN-PP	9.29 ± 2.80	9.86 ± 3.09	9.67 ± 2.35	ns			
5	MP-PP	27.87 ± 3.86	27.92 ± 4.15	28.49 ± 4.13	ns			
6	SN-MP	36.73 ± 3.71	38.18 ± 4.12	37.90 ± 4.72	**	*	*	
7	N-ANS	49.16 ± 2.84	50.65 ± 3.22	50.23 ± 2.95	***	***	***	
8	ANS-Me	60.23 ± 4.79	60.15 ± 4.67	60.50 ± 4.42	ns			
9	SN⊥ANS	49.45 ± 2.45	50.74 ± 2.79	50.23 ± 3.02	***	***	*	*
10	SN⊥PNS	41.34 ± 3.31	41.87 ± 3.27	42.45 ± 3.03	***	***	***	*
11	SV⊥A	56.24 ± 4.17	56.88 ± 4.59	56.30 ± 4.34	**	***		*
12	SV⊥B	44.29 ± 4.91	44.06 ± 5.48	43.99 ± 5.58	ns			
13	SN-U1P	102.53 ± 5.09	103.89 ± 4.76	103.18 ± 5.26	*	*		
14	SV⊥U1	55.39 ± 4.67	56.89 ± 5.06	55.91 ± 4.66	***	***		*
15	L1P-MP	93.07 ± 4.93	92.70 ± 5.29	91.73 ± 4.16	ns			
16	SV⊥L1	52.19 ± 4.52	52.13 ± 5.15	52.03 ± 4.94	ns			
17	UL-E	−2.04 ± 1.85	−1.61 ± 1.67	−1.78 ± 1.77	ns			
18	LL-E	−0.85 ± 1.86	−0.70 ± 1.66	−1.15 ± 1.71	ns			
Frontal cephalometric measurements								
19	NC-CN	31.39 ± 2.30	32.16 ± 2.34	31.63 ± 2.63	***	***	ns	**
20	JL-JR	62.57 ± 2.68	63.27 ± 3.05	62.85 ± 3.10	***	***	ns	ns
Dental cast measurements								
21	UC-UC	30.95 ± 2.11	36.34 ± 2.07	35.32 ± 1.93	***	***	***	***
22	UM-UM	45.01 ± 2.31	46.46 ± 1.71	46.35 ± 1.90	***	***	***	
23	LC-LC	26.51 ± 2.77	27.36 ± 4.24	26.64 ± 2.43	ns			
24	LM-LM	41.62 ± 2.00	42.57 ± 4.76	41.68 ± 1.88	ns			

[a] FRME indicates fan-type rapid maxillary expansion; RME, rapid maxillary expansion; RM-ANOVA, repeated-measures analysis of variance; T1, pretreatment; T2, posttreatment; T3, postretention; and SD, standard deviation. * $P < .05$; ** $P < .01$; *** $P < .001$; $P > .05$, ns, nonsignificant.

($P < .05$). There was no difference in retention in either group.

In the FRME group, retention was associated with a significant decrease in UC-UC distances ($P < .001$). In the RME group, retention was associated with a significant decrease in UC-UC and UM-UM distances ($P < .001$). The decrease in UM-UM distance was significantly greater in the RME group ($P < .001$).

DISCUSSION

The transversal deficiency problems of all subjects were corrected. The hypothesis was rejected. When the sagittal dimension was evaluated, any possible changes could be determined using SNA angle and SV⊥A distance. In both groups, the maxilla showed a significant increase in the measurements at treatment, which is parallel to the findings of some authors.[3,4,9,12,13] Moreover, the increase in SNA angle was significantly stable at the retention period in both groups. Conversely, some other investigators[1,9] found that there was no significant alteration in SNA angle; 1.30° and 0.52° increments of SNA were found in the FRME group and the RME group (T1-T3), respectively.

A significant reduction in SV⊥A distance was observed during retention in both groups; thus, there was no difference in either group (T1-T3). That finding is similar to the results of some other authors.[1,4,9] Doruk et al.[10] evaluated FRME in permanent dentition and found that SV⊥A distance was increased by 2.59 mm. They suggested a reason for this increase that the rotational opening of FRME can produce a buttressing effect on the skeletal structures behind the maxilla and therefore maxilla may be pushed forward by FRME in sagittal plane. This departure from the results of our study may also be explained by bone maturation and the permanent dentition of the samples of Doruk et al. Furthermore, the expansion duration of their study was approximately 5 days longer than that of ours, and this may have resulted in the extended effect of the appliance. Moreover, in the present study, point A moved forward in 17 patients in the FRME group and in 19 patients in the RME group. Thus, FRME and RME have similar effects on the maxilla in the sagittal plane, with some individual differences. The reduction of this measurement in the retention phase was parallel to the findings of some authors[3,4,14] and opposed to those of others.[15,16]

Table 2. Extended

RME Group						
T1 Mean ± SD	T2 Mean ± SD	T3 Mean ± SD	RM-ANOVA	T1-T2	T1-T3	T2-T3
Lateral cephalometric measurements						
77.25 ± 3.13	78.67 ± 3.16	77.78 ± 3.59	***	***	*	*
74.92 ± 3.21	75.22 ± 3.14	75.37 ± 3.38	*		*	
2.33 ± 1.76	3.45 ± 1.82	2.40 ± 1.52	***	***		*
8.07 ± 2.64	8.16 ± 2.93	7.87 ± 2.7	ns			
32.16 ± 5.86	32.84 ± 5.72	33.19 ± 5.68	*	*	*	
40.21 ± 5.46	41.01 ± 5.32	41.00 ± 4.15	**	*	*	
49.21 ± 2.12	50.11 ± 2.18	50.02 ± 2.22	***	**	**	
62.26 ± 3.44	62.80 ± 4.01	62.98 ± 3.61	*		*	
49.15 ± 1.89	50.14 ± 2.01	49.79 ± 2.21	***	**	*	
42.26 ± 2.29	43.09 ± 2.40	43.40 ± 2.53	***	***	***	
53.82 ± 3.30	54.52 ± 3.27	54.11 ± 3.57	**	***		*
42.66 ± 4.07	41.98 ± 4.83	42.46 ± 4.22	ns			
103.65 ± 6.63	102.73 ± 7.06	102.92 ± 6.84	ns			
53.25 ± 4.22	54.28 ± 4.27	53.99 ± 4.85	***	***	*	
90.70 ± 5.16	90.25 ± 5.58	90.06 ± 5.47	ns			
50.76 ± 4.34	50.41 ± 4.40	50.65 ± 4.62	ns			
−1.50 ±2.05	−1.50 ± 2.47	−2.01 ± 2.42	ns			
0.19 ± 1.98	0.09 ± 2.18	−0.29 ± 1.93	ns			
Frontal cephalometric measurements						
31.28 ± 2.56	33.03 ± 2.22	32.63 ± 2.22	***	***	***	*
61.27 ± 3.01	63.18 ± 2.63	62.56 ± 2.53	***	***	***	*
Dental cast measurements						
29.32 ± 2.41	34.46 ± 2.81	32.88 ± 3.11	***	***	***	***
43.30 ± 3.11	48.74 ± 3.81	47.53 ± 3.48	***	***	***	***
25.86 ±1.92	26.49 ± 2.11	26.42 ± 1.99	*	**	*	
42.25 ± 3.91	42.57 ± 3.94	42.23 ± 3.86	ns			

[a] FRME indicates fan-type rapid maxillary expansion; RME, rapid maxillary expansion; RM-ANOVA, repeated-measures analysis of variance; T1, pretreatment; T2, posttreatment; T3, postretention; and SD, standard deviation. * $P < .05$; ** $P < .01$; *** $P < .001$; $P > .05$, ns, nonsignificant.

To assess the vertical position, N-ANS, SN ⊥ ANS, and SN ⊥ PNS distances and the SN-PP angle may be used.[1,3,4,8,10,17] In both groups, there was no significant alteration in SN-PP angle, parallel to the results of one author.[9] N-ANS, SN ⊥ ANS, and SN ⊥ PNS distances showed significant increases both posttreatment and postretention in both groups, and these were approximately 1.19 mm, 1.14 mm, and 0.68 mm, respectively. Those values were very close together; according to geometric rules, we thought that the SN-PP angle was stable because of inferior parallel movement of the maxillary plane. The increases in these measurements signify the forward and downward movements of the maxilla, and many investigators[4,9,10,15,17,18] have shown similar RME results. Upper facial height increased significantly by distance, but angular measurements did not support these findings.

Many researchers[1,3,4,8,10,14,17] have stated that RME has some effects on the position of the mandible in the sagittal dimension. The determination of the mandibular projection SNB angle and SV ⊥ B distance may be utilized. In the RME group, a mean increase of 0.45° in the SNB angle was significant (T1-T3). However, SV ⊥ B distance did not support this outcome, and there were no clinically important alterations in the position of the mandible in both groups. There was a nearly 1.12° ($P < .05$) increment of SN-MP angle in the FRME group (T1-T3) and an 0.79° increment ($P < .05$) in the RME group. ANS-Me distance and MP-PP angle showed a statistically significant increase ($P < .05$) in the RME group (T1-T3) but no difference in the FRME group. In addition, when the two groups were compared, no statistically significant difference was found for these measurements.

The maxillomandibular relations in sagittal plane, namely ANB and MP-PP angles and ANS-Me distance, have shown some alterations in many studies[1,3,4,8,10,14,17] after RME in mixed dentition. In the FRME group, only an increase in the ANB angle ($P < .001$) was observed (T1-T3). This result was similar to the findings of a study[10] about the FRME in permanent dentitions. This could be a result of an anteriorly positioned point A, because there were no significant alterations in the SNB angle and SV ⊥ B distance. In the RME group, the increase in the ANB angle ($P < .001$) was observed (T1-T3), but it relapsed (T1-T3),

Table 3. Changes and Comparisons of Pretreatment, Posttreatment, and Postretention Values Within and Between the Groups[a]

		FRME Group		
		T1-T2 Mean ± SD	T1-T3 Mean ± SD	T2-T3 Mean ± SD
Lateral cephalometric measurements				
1	SNA	1.68 ± 0.71	1.30 ± 0.94	−0.38 ± 1.01
2	SNB	0.29 ± 1.53	−0.15 ± 1.28	−0.44 ± 1.57
3	ANB	1.43 ± 1.20	1.48 ± 0.74	0.05 ± 1.20
4	SN-PP	0.57 ± 1.55	0.37 ± 1.26	−0.19 ± 1.33
5	MP-PP	0.05 ± 2.17	0.61 ± 2.30	0.57 ± 2.28
6	SN-MP	1.45 ± 1.60	1.16 ± 1.47	−0.28 ± 1.58
7	N-ANS	1.48 ± 0.94	1.06 ± 1.06	−0.42 ± 1.14
8	ANS-Me	−0.09 ± 2.09	0.27 ± 2.50	0.35 ± 1.70
9	SN ⊥ ANS	1.30 ± 1.00	0.78 ± 1.27	−0.51 ± 0.85
10	SN ⊥ PNS	0.53 ± 0.46	1.11 ± 1.03	0.58 ± 1.08
11	SV ⊥ A	0.64 ± 0.66	0.06 ± 1.19	−0.58 ± 1.19
12	SV ⊥ B	−0.23 ± 1.59	−0.30 ± 1.69	−0.07 ± 1.46
13	SN-U1P	1.36 ± 2.39	0.64 ± 2.70	−0.71 ± 2.31
14	SV ⊥ U1	1.50 ± 0.87	0.53 ± 0.69	−0.97 ± 1.68
15	L1P-MP	−0.37 ± 1.97	−1.34 ± 2.95	−0.97 ± 3.37
16	SV ⊥ L1	−0.05 ± 1.63	−0.15 ± 1.73	−0.10 ± 1.94
17	UL-E	0.43 ± 1.58	0.25 ± 1.44	−0.17 ± 0.95
18	LL-E	0.15 ± 1.33	−0.53 ± 1.99	−0.45 ± 1.10
Frontal cephalometric measurements				
19	NC-CN	0.76 ± 0.74	0.23 ± 1.02	−0.52 ± 0.83
20	JL-JR	0.70 ± 0.71	0.28 ± 0.92	−0.41 ± 0.89
Dental cast measurements				
21	UC-UC	5.38 ± 1.65	4.37 ± 1.82	−1.01 ± 0.99
22	UM-UM	1.44 ± 0.96	1.33 ± 1.23	−0.11 ± 0.37
23	LC-LC	0.84 ± 2.00	0.12 ± 0.87	0.71 ± 2.35
24	LM-LM	0.95 ± 3.94	0.06 ± 0.77	0.03 ± 0.60

[a] FRME indicates fan-type rapid maxillary expansion; RME, rapid maxillary expansion; RM-ANOVA, repeated-measures analysis of variance; T1, pretreatment; T2, posttreatment; T3, postretention; and SD, standard deviation. * $P < .05$; ** $P < .01$; *** $P < .001$; $P > .05$, ns, nonsignificant.

and this finding was opposite to those of some studies.[3,4] The increment of the SNB angle ($P < .05$) may be the reason for the relapse of ANB (T2-T3).

A clockwise rotation of the mandible was present in the RME group because of the significant increases of the MP-PP angle and ANS-Me distance ($P < .05$) (T1-T3). That would be a reason for the increase in lower facial height and inferior and posterior movement of the mandible. Moreover, in both groups, the SN-MP angle significantly increased ($P < .05$) (T1-T2 and T1-T3), and there was no significant difference between the two groups. The increases in all vertical dimensions were significantly greater in the RME group. Such results may be found in the literature.[4,8,17] This result may also have occurred because the buccal tipping and extrusion of the palatinal cusps of the anchoring molars of the RME group were greater, as the biomechanical properties of FRME probably reduced the buccal tipping of the posterior teeth. The inferior and posterior rotations of the mandible were significant in relation to the cranial base (SN-MP) and the palatal plane (MP-PP). In addition, these types of distance increases may be the reason for the increase in total face height.

In the current study we found an increase in the SN-U1P angle ($P < .05$) in the FRME group only after treatment, and we found no difference in the RME group. Moreover, there was only a significant difference ($P < .05$) for this angle between the two groups in the T1-T2 period. In both groups, the SV ⊥ U1 distance showed a significant increment ($P < .001$) after treatment, and this was relapsed in the FRME group. In a FRME investigation[10] of the permanent dentition, significant increases were found in those measurements. One author[14] suggested that the U1-SN angle decreased because of angulations of incisors independent from the maxilla; other authors[3] stated that the inferior rotation of the palatal plane resulted in the decrease of this angle. The upper incisors showed a stable position according to some investigators[9] and a protrusive position according to others.[4,17] Furthermore, in our study, the value of the SN-U1P angle should be considered carefully, because a method

Table 3. Extended

RME Group			Difference Between Groups			
T1-T2 Mean ± SD	T1-T3 Mean ± SD	T2-T3 Mean ± SD	RM-ANOVA	T1-T2	T1-T3	T2-T3
1.41 ± 0.63	0.52 ± 1.17	−0.86 ± 1.11	*		*	
0.30 ± 1.01	0.45 ± 1.00	0.15 ± 1.26	ns			
1.11 ± 1.01	0.06 ± 1.18	−1.04 ± 1.25	***		***	**
0.09 ± 1.33	−0.19 ± 1.02	−0.28 ± 1.15	ns			
0.68 ± 1.34	1.02 ± 1.49	0.35 ± 1.46	ns			
0.79 ± 1.47	0.79 ± 1.65	−0.00 ± 1.48	ns			
0.89 ± 1.23	0.80 ± 1.24	−0.08 ± 1.91	ns			
0.54 ± 1.71	0.71 ± 1.22	0.17 ± 1.45	ns			
0.99 ± 1.22	0.63 ± 1.11	−0.35 ± 1.68	ns			
0.83 ± 0.90	1.14 ± 1.06	0.31 ± 085	ns			
0.70 ± 0.48	0.29 ± 1.06	−0.40 ± 0.86	ns			
−0.68 ± 2.18	−0.20 ± 2.22	0.48 ± 1.98	ns			
−0.92 ± 2.61	−0.73 ± 3.05	0.19 ± 2.88	*	*		
1.02 ± 0.96	0.74 ± 1.37	−0.28 ± 1.37	ns			
−0.45 ± 2.12	−0.63 ± 1.72	−0.18 ± 1.60	ns			
−0.35 ± 1.90	−0.11 ± 1.45	0.24 ± 1.42	ns			
0.00 ± 0.90	−0.51 ± 1.18	−0.51 ± 1.29	ns			
−0.10 ± 1.35	0.61 ± 2.79	−0.38 ± 0.98	ns			
1.75 ± 1.38	1.35 ± 1.09	−0.39 ± 0.74	**	**	**	
1.91 ± 1.38	1.28 ± 1.43	−0.62 ± 1.15	**	**	*	
5.13 ± 2.02	3.56 ± 1.96	−1.57 ± 1.25	ns			
5.43 ± 2.54	4.22 ± 2.33	−1.20 ± 1.02	***	***	***	***
0.52 ± 0.92	0.55 ± 0.99	0.06 ± 0.82	ns			
0.32 ± 1.22	−0.01 ± 1.38	−0.34 ± 0.97	ns			

[a] FRME indicates fan-type rapid maxillary expansion; RME, rapid maxillary expansion; RM-ANOVA, repeated-measures analysis of variance; T1, pretreatment; T2, posttreatment; T3, postretention; and SD, standard deviation. * $P < .05$; ** $P < .01$; *** $P < .001$; $P > .05$, ns, nonsignificant.

error of 0.71° was found. There were no significant alterations for lower incisors. Moreover, the soft tissue measurements did not change in either groups, a finding similar to that of other authors.[17]

In terms of the nature of RME, the measurements were greater in the transverse dimension than in the sagittal dimensions. There were significant increases ($P < .001$) in nasal cavity width and maxillary basal width in both groups, and these measurements showed relapse during the retention period in the FRME group. In addition, the increments of the RME group were significantly higher ($P < .01$) than those of the FRME group. The findings for the RME group were similar to those of many investigators.[1,4,9,12,17,19] After a FRME in the permanent dentition, Doruk et al.[10] found significant and stable increments in nasal cavity width. Thus, it could be expected that the expansion of the nasal cavity after RME in the early period may be reliable compared to that expected with the FRME.

In the dental cast evaluation of transverse dimension, the upper intermolar and intercanine widths increased significantly ($P < .001$) (T1-T3) in both groups. However, the increment of intermolar width was significantly ($P < .01$) greater in the RME group, as expected because of the biomechanics of the FRME appliance. Many researchers[1,4,8,9,12,15,17,19] observed the same results. Furthermore, in the FRME group, the ratio of the intercanine to the intermolar width was close to 3.5:1, which was different from that of the RME group. Doruk et al.[10] found in permanent dentitions that the ratio of intercanine to intermolar width was nearly 3:1. This might be expected because of the mobility of the primary canines used in the measurement at this mixed dentition phase. In addition, there was no therapy for the mandible; however, the lower intercanine width increased significantly with treatment ($P < .001$) and retention ($P < .05$) in the RME group. This expansion might have occurred because the expansion need of the RME group was greater, resulting in passive expansion, or because the primary canines showed higher mobility than in the FRME group. Lastly, a method error of 0.31 mm was found for this distance, and that requires careful consideration. Evaluation of longer retention (ie, 3–4-year) times for both groups in the mixed dentition should be a topic of future studies.

CONCLUSIONS

Within the limits of this study,

- The maxilla moved downward and forward in both groups after expansion therapy;
- The nasal cavity and maxillary widths were more expanded in the RME group, and there were only a few relapses in this group during retention;
- There was significant labial tipping of the upper incisors in the FRME group; and
- The expansion of intercanine width was similar in both groups, but the expansion of intermolar width was significantly greater in the RME group than in the FRME group.

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