Original Article

Rapid Maxillary Expansion. Is it Better in the Mixed or in the Permanent Dentition?

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Abstract: The aim of this study was to compare the dentoskeletal effects of a modified acrylic-bonded rapid maxillary expansion (RME) device when it is used in the mixed and permanent dentitions. The study group consisted of 51 patients in the mixed and permanent dentition (26 girls and 25 boys) who underwent RME treatment. Group 1 was composed of 34 subjects in the mixed dentition (19 girls and 15 boys; mean age, 9.2 $\pm$ 1.3 years). Group 2 consisted of 17 subjects in the permanent dentition (seven girls and 10 boys; mean age 12.7 $\pm$ 1.2 years). Lateral and frontal cephalograms and upper dental casts were collected before treatment (T1), after treatment (T2), and after retention (T3). Intragroup and intergroup changes were evaluated by paired *t*-test and Student's *t*-test, respectively. In both groups after RME, the maxilla moved forward; mandible rotated posteriorly; facial height increased; nasal, maxillary, and maxillary intercanine and first molar widths increased; and the upper molars tipped buccally. Almost all these significant changes were stable at follow-up (T3). When overall (T1 − T3) differences were considered, upper molars tipped more, and the ANB angle increased less in the mixed dentition group compared with the permanent dentition group ($P < .01$). Within the limits of this study, the results suggest that the orthopedic effects of RME are not as great as expected at early ages, and it might be a better alternative to delay RME to early permanent dentition. (*Angle Orthod* 2003;73:654–661.)

Key Words: Rapid maxillary expansion; Mixed dentition; Early treatment

INTRODUCTION

The present concepts concerning posterior crossbites are well defined in the literature and are widely accepted by orthodontists.[1] Posterior crossbite is one of the most frequently observed malocclusions of the different dentition periods.[2] This entity may occur in the primary or mixed dentition and manifest itself as a constriction in the lateral dimensions of the upper arch. Among 965 Turkish children, in the region of Konya, Turkey, a 9.5% incidence of posterior crossbite was found.[3] The prevalence of this malocclusion in the deciduous dentition was reported to be 8% by Kutin and Hawes[4] and in the mixed dentition, 12% by Hanson et al[5] and 2.7% by Sandıkçıoğlu and Hazar.[6] Various investigators claim that this abnormality is not self-correcting, and they recommend treatment at an early period.[4,7–10] On the basis of these concepts, it is necessary to correct this form of malocclusion as early as possible.

Many different methods have been used to expand the constricted maxillary arches. When evaluated on the basis of the frequency of the activations, magnitude of the applied force, duration of the treatment, and the patient's age, different mechanics produce rapid, semirapid, and slow expansions.[6] In rapid maxillary expansion (RME) procedures, indicated for the correction of skeletal constriction, even in early occlusal development stages, many orthodontists use the jackscrew in banded or bonded appliances, following the basic standards proposed by Haas[11] with a few modifications.

Slow expansion appliances do promote a slight opening in the median palatine suture in the primary and mixed dentition stages.[12–14] However, cephalometrically and clinically, the results cannot be compared with the orthopedic effects of the Haas-type of appliance.[15] RME increases the upper arch transverse dimensions mainly by separation of the two maxillary halves (orthopedic effect), followed by buccal movement of the posterior teeth and alveolar processes (orthodontic effect).[1]

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Skeletal changes tend to be less significant with skeletal maturity because of the increased rigidity of the articulations of the maxilla with the face,[16] which can be felt clinically by the patient either as discomfort or as pain.

Although the use of RME procedures in the primary and mixed dentitions are mentioned in the literature,[12,16–19] only a few[1,2,6] have been published concerning the specific alterations induced by these procedure in these early occlusal developmental stages.

Therefore, the aims of this study were (1) to evaluate specific dental and skeletal changes induced by the treatment of posterior crossbite in the mixed dentition with RME and (2) to compare these changes with those achieved in the permanent dentition.

MATERIALS AND METHODS

A total of 51 patients (25 boys and 26 girls) were included in this study. The subjects in group 1 (mixed dentition group) comprised 34 children (19 girls and 15 boys) with a mean age of 9.2 ± 1.3 years. The subjects in group 2 (permanent dentition group) comprised 17 children (seven girls and 10 boys) with a mean age of 12.7 ± 1.2 years. All children had posterior crossbites with skeletal involvement.

A splint-type tooth and tissue–borne appliance described elsewhere was used for RME.[20,21] The acrylic part of the appliance extended over the occlusal 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. A Hyrax screw (602–813, Dentaurum, Ispringen, Germany) was placed in the acrylic plate parallel to the second premolars or deciduous molars as close to the palate as possible. The arms of the Hyrax screw were not cut off but were bent to get into contact with the anchorage teeth. This increased the rigidity of the appliance. In both groups, the appliance was activated one-quarter turn twice a day in the first week to overcome the resistance of the sutures and once a day after the sutures were mobilized.

Expansion was considered adequate when the occlusal aspect of the maxillary lingual cusp of upper first molars contacted the occlusal aspect of the facial cusp of the mandibular lower first molars. The 2–3 mm overexpansion was designed to compensate for relapse after expansion. The appliance used in active treatment was cleaned and used as a removable retention appliance. Retention period lasted 25 weeks in group 1 and 12.9 weeks in group 2. At the end of this period, postretention (T3) records were collected, and observation period was continued in group 1, and orthodontic treatment was initiated in group 2.

Lateral and frontal cephalometric radiographs and upper and lower plaster models were taken before treatment (T1), after treatment (T2), and after retention (T3). The measurements performed are presented in Figures 1 through 3. The landmarks were identified according to the definitions provided by Basciftci and Karaman.[20]

For the assessment of changes in molar torque values on frontal cephalometric films, Chrome-Cobalt cast onlays, which covered the occlusal surfaces of the left and right

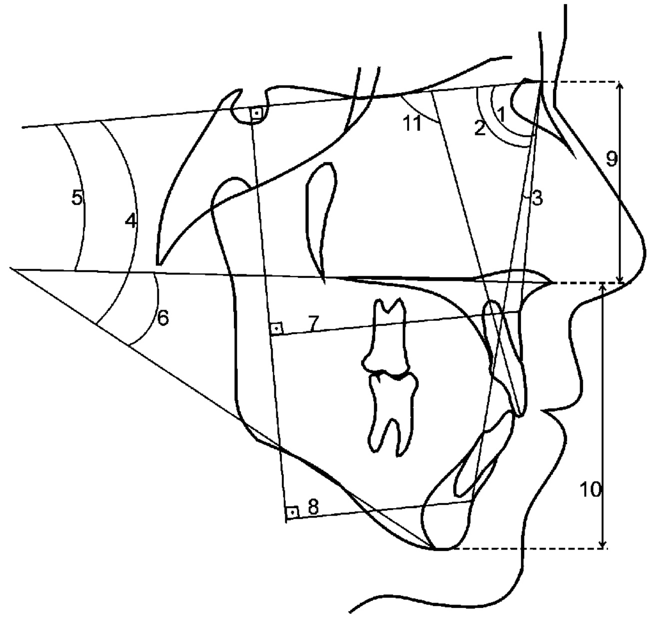

FIGURE 1. Lateral cephalometric measurements: 1, SNA; 2, SNB; 3, ANB; 4, SN-MP; 5, SN-PP; 6, PP-MP; 7, SV ⊥ A; 8, SV ⊥ B; 9, N-ANS; 10, ANS-Me; 11, U1-SN.

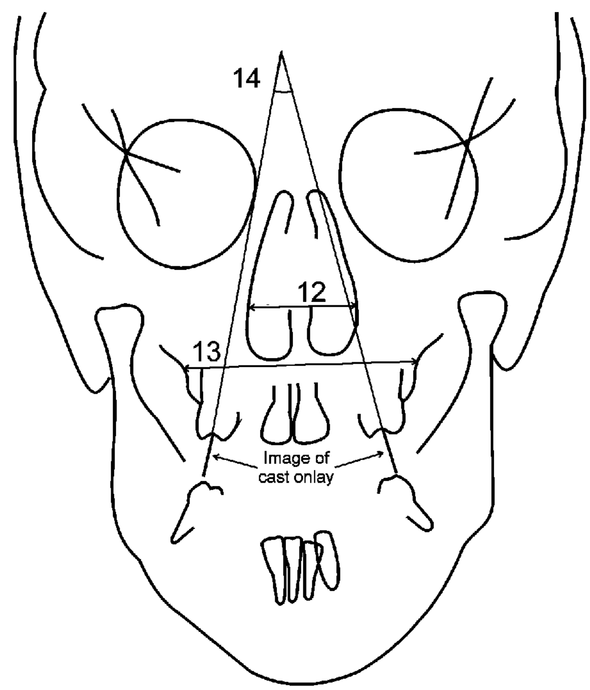

FIGURE 2. Frontal cephalometric measurements: 12, NC-CN; 13, JL-JR; 14, angle between upper first molars.

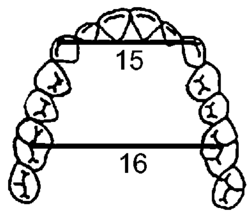

FIGURE 3. Dental cast measurements: 15, width between upper canines; 16, width between upper first molars.

TABLE 1. Error of the Method

	Measurement	Dahiberg's Calculation
1	SNA (°)	0.360
2	SNB (°)	0.331
3	ANB (°)	0.221
4	SN-MP (°)	0.729
5	SN-PP (°)	0.441
6	MP-PP (°)	0.646
7	SV ⊥ A (mm)	0.300
8	SV ⊥ B (mm)	0.620
9	N-ANS (mm)	0.474
10	ANS-Me (mm)	0.841
11	U1-SN (°)	0.93
12	NC-CN (mm)	0.494
13	JL-JR (mm)	0.542
14	Angle between upper first molars (°)	0.207
15	Width between upper canines (mm)	0.253
16	Width between upper first molars (mm)	0.361

upper first molars was prepared by the dental laboratory on each pretreatment working model.[22] This onlay had a vertical spur that was 0.9 mm thick and 10 mm long and prepared as vertical as possible to the occlusal surface of the tooth. These Cr-Co cast onlays were cemented temporarily on the occlusal surfaces of the molar tooth using polycarboxylate luting cement. After the exposure of the frontal cephalograms, the onlays were removed from the occlusal surface. The same onlays were stored, sterilized, and reused for all frontal cephalograms.

Statistical method

The mean differences between different time points were evaluated using the paired *t*-test. Independent-samples *t*-test was applied for comparison of the groups. All statistical analyses were performed using the SPSS software package (SPSS for Windows, version 10.0.1, SPSS Inc, Chicago, Ill).

Two weeks after the first measurements, 30 randomly selected radiographs were retraced and redigitized. A paired-samples *t*-test was applied to the first and second measurements. The difference between the first and second measurements of the 30 radiographs was insignificant. Correlation analysis yielded the highest *r* value, 0.99, for SV ⊥ A and the lowest *r* value, 0.93, for MP-PP measurements.[23]

The method error was calculated by using Dahlberg's method error formula $\sqrt{\Sigma d^2/2n}$. Values changed from 0.207° to 0.935° and were within acceptable limits. The results are shown in Table 1.

RESULTS

Pretreatment vs posttreatment (T1–T2) (Table 2)

In group 1, treatment was associated with increases in the mean values for SN-MP, N-ANS, and ANS-Me ($P < .001$); SNA and MP-PP ($P < .01$); and ANB and SV ⊥ A ($P < .05$). Treatment induced reductions in the mean values

TABLE 2. Comparisons of Pre- and Posttreatment Values Between and Within the Groups

		Group I						
		Pretreatment (T1)		Posttreatment (T2)		Difference (T2 − T1)		Paired Samples *t*-Test[a]
		Mean	SD	Mean	SD	Mean	SD	
1	SNA	76.89	3.28	77.61	3.35	0.72	1.53	0.010**
2	SNB	74.55	3.29	74.61	3.11	0.06	1.68	NS
3	ANB	2.33	2.37	3.00	2.19	0.66	0.21	0.026*
4	SN-MP	37.75	4.32	39.64	3.89	1.90	1.70	0.000***
5	SN-PP	8.20	2.72	8.75	3.61	0.54	1.96	NS
6	MP-PP	29.54	4.69	30.89	5.21	1.35	2.40	0.002**
7	SV ⊥ A	51.13	4.37	51.89	3.94	0.76	1.90	0.025*
8	SV ⊥ B	39.3	6.01	37.95	5.4	−1.35	1.84	0.000***
9	N-ANS	48.98	2.89	49.7	2.87	0.72	0.81	0.000***
10	ANS-Me	64.41	3.89	66.44	4.48	2.03	2.15	0.000***
11	U1-SN	98.17	7.36	98.72	6.11	0.54	4.12	NS
12	NC-CN	29.75	3.01	31.35	2.82	1.60	1.69	0.000***
13	JL-JR	64.14	4.47	66.05	4.28	1.91	2.1	0.000***
14	Angle between upper first molars	15.18	10.49	26.15	10.47	10.97	4.61	0.000***
15	Width between upper canines	30.21	2.65	35.58	2.86	5.37	1.57	0.047*
16	Width between upper first molars	44.45	3.68	49.81	3.09	5.36	3.02	0.000***

[a] * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS, nonsignificant.

for SV ⊥ B ($P < .001$). In group 2, treatment was associated with increases in the mean values for SNA, ANB, and SN-MP ($P < .001$); MP-PP, SV ⊥ A, and ANS-Me ($P < .01$); and SNB, SV ⊥ B, and N-ANS ($P < .05$). The increase of ANB was significantly greater in group 2 ($P < .05$), whereas increases of SNB and U1-SN measurements were significantly greater in group 1 ($P <$ 05).

The PA measurements in group 1 showed that the mean posttreatment values were greater than the mean pretreatment values for NC-CN, JL-JR, and intermolar angle ($P < .001$). Similarly, in group 2, the mean posttreatment values were greater than the mean pretreatment values for NC-CN, JL-JR, and intermolar angle ($P < .001$). The difference for group 1 was larger than that for group 2 for the intermolar angle ($P < .001$).

Measurements of the dental cast in group 1 showed that the posttreatment values were greater than the pretreatment values for the upper intercanine width ($P < .05$) and the upper first molar width ($P < .001$). However, in group 2, both the upper intercanine and first molar widths were greater in the posttreatment group than in the pretreatment group at $P < .001$ significance level. There were no statistically significant mean differences between the posttreatment and postretention values for group 1 when compared with those for group 2.

Pretreatment vs postretention (T1–T3) (Table 3)

In group 1, when the T3 values were compared with the T1 values, significant increases were present at SNA and N-ANS ($P < .01$ and $P < .001$, respectively), SV ⊥ A and ANS-Me ($P < .01$), and SN-MP and MP-PP ($P < .05$). In group 2, when the T3 values were compared with the T1 values, SNB was significantly decreased ($P < .05$) and SNA, ANB, and SN-MP ($P < .001$); MP-PP, SV ⊥ A, ANS-Me ($P < .01$), and N-ANS ($P < .05$) were significantly increased. The increase of the ANB angle was significantly greater in group 2 ($P < .01$).

The PA measurements in group 1 showed that the mean pretreatment values were less than the mean postretention values for NC-CN, JL-JR, and intermolar angle ($P < .001$). Similarly, in group 2 the mean postretention values were greater than the mean pretreatment values for NC-CN, JL-JR, and intermolar angle ($P < .001$). The difference for group 1 was larger than that for group 2 for the intermolar angle ($P < .01$).

In group 1, the cast evaluations showed that the postretention values were greater than the pretreatment values for the upper intercanine width ($P < .05$) and the upper first molar width ($P < .001$). In group 2, both the upper intercanine and first molar widths were greater in the postretention group than in the pretreatment group at the $P < .001$ significance level. The difference for group 2 was larger than that for group 1 for the upper first molar width ($P < .01$).

Posttreatment vs postretention (T2–T3) (Table 4)

In group 1, the SN-MP measurement was significantly increased at T3 ($P < .01$). In group 2, ANB and SN-MP were significantly decreased ($P < .01$), and the SV ⊥ B measurement was significantly increased at T3 ($P < .01$).

Neither group 1 nor group 2 showed any statistically significant differences between posttreatment and postretention values of PA measurements. The difference for group 2 was larger than that for group 1 for the intermolar angle ($P < .001$).

Measurements of the models showed that the postreten-

TABLE 2. Extended

Group II							
Pretreatment (T1)		Posttreatment (T2)		Difference (T2 − T1)		Paired Samples *t*-Test	Independent Samples *t*-Test
Mean	SD	Mean	SD	Mean	SD		
78.09	3.7	79.53	3.15	1.44	1.37	0.000***	NS[a]
76.03	2.91	75.29	2.87	−0.74	1.16	0.019*	0.047*
2.06	2.32	4.24	1.97	2.18	1.27	0.000***	0.032*
39.09	7.26	40.94	7.17	1.85	1.37	0.000***	NS
9.65	2.66	8.94	2.34	−0.71	1.87	NS	NS
29.5	6.52	30.71	6.6	1.21	1.36	0.002**	NS
50.91	6.54	52.56	6.56	1.65	2.01	0.004**	NS
38.26	9.58	37.18	10.04	−1.09	1.74	0.020*	NS
55.32	3.25	56.62	3.44	1.30	2.39	0.040*	NS
68.56	4.63	71.15	5.56	2.59	3.10	0.003**	NS
103.71	7.28	102.5	6.07	−1.21	3.83	NS	0.032*
30.53	2.65	34.03	2.73	3.50	1.00	0.000***	NS
61.53	3.56	66.47	3.24	4.94	1.75	0.000***	NS
14.33	9.68	19.39	10.41	5.06	3.77	0.000***	0.000***
34.23	2.57	40.29	4.38	6.06	2.45	0.000***	NS
45.01	2.35	51.78	3.07	6.77	2.02	0.000***	NS

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

		Group I						
		Pretreatment (T1)		Postretention (T3)		Difference (T3 − T1)		Paired Samples *t*-Test[a]
		Mean	SD	Mean	SD	Mean	SD	
1	SNA	76.89	3.28	77.44	3.35	0.54	1.08	0.006**
2	SNB	74.55	3.29	74.89	3.22	0.34	1.45	NS
3	ANB	2.33	2.37	2.54	2.11	0.21	1.41	NS
4	SN-MP	37.75	4.32	38.6	4.14	0.85	2.1	0.024*
5	SN-PP	8.20	2.72	8.57	3.94	0.37	2.39	NS
6	MP-PP	29.54	4.69	30.35	4.94	0.81	2.27	0.045*
7	SV ⊥ A	51.13	4.37	51.91	4.25	0.78	1.63	0.009**
8	SV ⊥ B	39.30	6.01	39.05	5.89	−0.25	2.51	NS
9	N-ANS	48.98	2.89	50.02	2.77	1.04	1.14	0.000***
10	ANS-Me	64.41	3.89	65.91	4.11	1.5	2.27	0.001**
11	U1-SN	98.17	7.36	98.45	6.36	0.28	4.76	NS
12	NC-CN	29.75	3.01	32.36	1.51	2.62	2.83	0.000***
13	JL-JR	64.14	4.47	66.04	3.70	1.9	1.86	0.000***
14	Angle between upper first molars	15.18	10.49	22.75	10.21	7.57	4.64	0.000***
15	Width between upper canines	30.21	2.65	34.72	2.71	4.51	1.34	0.016*
16	Width between upper first molars	44.45	3.68	48.69	2.70	4.24	3.00	0.000***

[a] * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS, nonsignificant.

tion values were less than the posttreatment values for the upper first molar width ($P < .001$) in group 1. In group 2, no statistically significant differences were found between posttreatment and postretention values for the upper intercanine and first molar widths. The difference for group 1 was larger than that for group 2 for the intercanine width and upper first molar width ($P < .01$).

DISCUSSION

RME is an orthodontic procedure routinely used when the constricted maxilla and upper dental arch demand orthopedic widening in the deciduous, mixed, and permanent dentition.[20] The purpose of this study was to compare the dental and skeletal results in transversal, sagittal, and vertical dimensions, and relapse tendencies after retention of RME in two different dentitional age periods.

In both groups, the maxilla showed statistically significant alterations in the posteroanterior (P-A) position, which is in accordance with the works of Haas,[11,18,25] Krebs,[26,27] and Wertz.[16] This finding is based on the angular and linear measurements used in the study to define the posteroanterior position of the maxilla, namely SNA and SV ⊥ A.

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

		Group I						
		Posttreatment (T2)		Postretention (T3)		Difference (T3 − T2)		Paired Samples *t*-Test[a]
		Mean	SD	Mean	SD	Mean	SD	
1	SNA	77.61	3.35	77.44	3.35	−0.18	1.38	0.46*
2	SNB	74.61	3.11	74.89	3.22	0.28	1.56	NS
3	ANB	3.00	2.19	2.54	2.11	−0.46	1.44	NS
4	SN-MP	39.64	3.89	38.6	4.14	−1.04	1.91	0.003**
5	SN-PP	8.75	3.61	8.57	3.94	−0.18	1.64	NS
6	MP-PP	30.89	5.21	30.35	4.94	−0.54	1.61	NS
7	SV ⊥ A	51.89	3.94	51.91	4.25	0.01	1.46	NS
8	SV ⊥ B	37.95	5.4	39.05	5.89	1.10	2.86	0.031*
9	N-ANS	49.70	2.87	50.02	2.77	0.32	1.16	NS
10	ANS-Me	66.44	4.48	65.91	4.11	−0.53	2.00	NS
11	U1-SN	98.72	6.11	98.45	6.36	−0.26	2.99	NS
12	NC-CN	31.35	2.82	32.36	1.51	1.01	3.00	NS
13	JL-JR	66.05	4.28	66.04	3.70	−0.01	1.63	NS
14	Angle between upper first molars	26.15	10.47	22.75	10.21	−3.39	3.66	0.000***
15	Width between upper canines	35.58	2.86	34.72	2.71	−0.86	0.85	NS
16	Width between upper first molars	49.81	3.09	48.69	2.7	−1.11	1.34	0.000***

[a] * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS, nonsignificant.

TABLE 3. Extended

Group II							
Pretreatment (T1)		Postretention (T3)		Difference (T3 − T1)		Paired Samples *t*-Test	Independent Samples *t*-Test
Mean	SD	Mean	SD	Mean	SD		
78.09	3.7	79.41	3.11	1.32	1.13	0.000***	NS[a]
76.03	2.91	75.53	2.88	−0.5	0.85	0.027*	NS
2.06	2.32	3.88	1.95	1.82	1.13	0.000***	0.003**
39.09	7.26	40.5	7.18	1.41	1.03	0.000***	NS
9.65	2.66	9.21	2.38	−0.44	1.66	NS	NS
29.5	6.52	30.68	6.49	1.18	1.4	0.003**	NS
50.91	6.54	52.32	6.29	1.41	1.73	0.004**	NS
38.26	9.58	37.71	9.83	−0.56	1.26	NS	NS
55.32	3.25	56.32	3.36	1	1.75	0.032*	NS
68.56	4.63	70.65	5.37	2.09	2.22	0.001**	NS
103.71	7.28	102.91	6.07	−0.79	2.96	NS	NS
30.53	2.65	33.88	2.53	3.35	0.9	0.000***	NS
61.53	3.56	66.39	3.24	4.86	1.64	0.000***	NS
14.33	9.68	19.21	10.34	4.88	3.64	0.000***	0.006**
34.23	2.57	40.14	4.42	5.91	2.55	0.000***	NS
45.01	2.35	51.68	3.08	6.68	1.99	0.000***	0.004**

However, Da Silva et al[1] indicated that the maxilla did not show any statistically significant alterations in the P-A position when the RME was used in the primary or mixed dentition. Anterior displacement of the maxilla is denoted by the 0.54° SNA ($P < .01$) and 0.78 mm SV ⊥ A ($P < .01$) increments (T1 − T3) in the mixed dentition group and by 1.32° SNA ($P < .001$) and 1.41 mm SV ⊥ A ($P < .01$) increments in the permanent dentition groups (T1 − T3).

In this study, point A demonstrated a slightly backward movement, as characterized by a decrease in the SNA angle and SV ⊥ A distance in the retention phase in both groups. However, no statistically significant differences were found. Decreases in these measurements in the retention period have been mentioned in some previous studies.[6,9,16] On the contrary, Davis and Kronman[28] reported that point A moved anteriorly in the retention phase.

Da Silva et al[1] in the mixed dentition and Haas[18] in the permanent dentition observed significant cephalometric alterations in the P-A position of the mandible, namely, the reduction of the mandibular projection. In the mixed dentition group, a mean reduction of 1.35 mm in the SV ⊥ B distance was statistically significant. However, the SNB angle did not support this finding. In the permanent dentition

TABLE 4. Extended

Group II							
Posttreatment (T2)		Postretention (T3)		Difference (T3 − T2)		Paired Samples *t*-Test	Independent Samples *t*-Test
Mean	SD	Mean	SD	Mean	SD		
79.53	3.15	79.41	3.11	−0.12	0.55	NS	NS[a]
75.29	2.87	75.53	2.88	0.24	0.50	NS	NS
4.24	1.97	3.88	1.95	−0.35	0.39	0.002**	NS
40.94	7.17	40.5	7.18	−0.44	0.46	0.001**	NS
8.94	2.34	9.21	2.38	0.26	1.08	NS	NS
30.71	6.60	30.68	6.49	−0.03	0.41	NS	NS
52.56	6.56	52.32	6.29	−0.24	0.73	NS	NS
37.18	10.04	37.71	9.83	0.53	0.67	0.005**	NS
56.62	3.44	56.32	3.36	−0.29	1.00	NS	NS
71.15	5.56	70.65	5.37	−0.5	1.13	NS	NS
102.50	6.07	102.91	6.07	0.41	1.62	NS	NS
34.03	2.73	33.88	2.53	−0.15	0.29	NS	NS
66.47	3.24	66.39	3.24	−0.08	0.18	NS	NS
19.39	10.41	19.21	10.34	−0.18	0.37	NS	0.002**
40.29	4.38	40.14	4.42	−0.16	0.33	NS	NS
51.78	3.07	51.68	3.08	−0.09	0.20	NS	NS

group, a statistically significant reduction of the SV ⊥ B was also observed but to a lesser extent when compared with the mixed dentition.

After maxillary expansion in the mixed dentition period, Sandikçioğlu and Hazar[6] stated that the change in the ANB angle could be a result of posterior rotation of point B. However, in the mixed dentition period, no statistically significant changes were observed in the SNB angle in this study. Therefore, the significant increase in the ANB angle should be a result of increases in the SNA angle.

The RME procedures induce statistically significant alterations in almost all vertical dimensions.[11,14,20] RME incited an increase in the vertical dimensions of the face because of the maxillary and mandibular downward and backward rotations. In the present study, SN-MP, MP-PP, N-ANS, and ANS-Me measurements increased in both groups but with a greater increase in the mixed dentition. This is possibly due to the greater buccal tipping of anchoring molars in this group (T1–T2, T1–T3). However, no statistically significant differences in these measurements were found between the two groups. The postural alterations of mandible denoted by downward and backward rotations may also be linked to the buccal tipping and extrusion of the upper first molars. The downward and backward rotations were significant in relation to the cranial base (SN-MP) and the palatal plane (MP-PP).

The use of RME results in a downward movement of the maxilla, more at PNS, which results in an increase in the palatal plane angle upper facial dimensions and total facial dimensions.[1,11,16,18–20,25,29,30] However, in this study, no vertical alterations were found in the maxilla in relation to the cranial base (SN-PP) in any of the groups.

Wertz[16] found a clear decrease in the U1-SN angle and indicated that angulation of incisors showed either an increase or a decrease, independent from the maxilla. Sandikçioğlu and Hazar[6] also denoted a decrease in this angle. They interpreted this movement of incisors as a result of the inferior rotation of the palatal plane. In this study, a statistically significant difference for the U1-SN angle was found between two groups only in the T1–T2 period. The U1-SN angle increased in the mixed dentition and decreased in the permanent dentition (T1–T2: $P < .05$). The palatal plane showed no statistically significant changes between the three different periods in any of the groups. However, the incisor position was different between the two groups in the T1–T2 period. This finding indicates a change in the inclination of the upper incisors independent of the palatal plane.

In both groups, changes in the transversal plane values were higher than the vertical and sagittal values as expected. Nasal cavity width and maxillary basal width showed statistically significant ($P < .001$) increases, and these were stable during the retention period in both groups (T2–T3). However, no significant differences were observed between the two treatment groups. These findings were consistent with those of Da Silva et al[1,31] and Basciftci et al.[32] RME in the early period does not seem to be a reliable alternative for nasal cavity expansion.

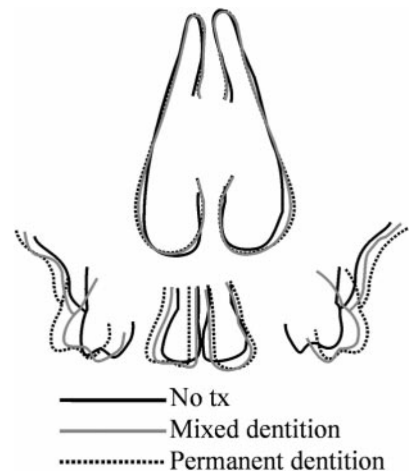

FIGURE 4. Schematic drawing of RME effects at various dental stages. Please note that the teeth or bone movement is exaggerated in the drawing for demonstration and may not reflect the actual changes presented in the tables.

The upper intercanine and intermolar widths increased significantly with treatment.[6,20,25,30,33–35] These increases were greater in the permanent dentition (T1–T3: $P < .01$). This might be an expected finding because the need for expansion might be greater in the permanent dentition group. However, when the relapse tendencies between the two groups were evaluated, the mixed dentition group showed more reduction of the intercanine and intermolar widths than did the permanent dentition group (T2–T3: $P < .01$) This indicates that expansion in the earlier period of development is not more stable.

Use of RME causes buccal bending of the alveolar structures in various degrees.[20,33,36,37] In this study, when overall (T1 − T3) differences were considered, upper molars tipped more in the mixed dentition group as compared with the permanent dentition group ($P < .01$), particularly between the T1 and T2 periods ($P < .001$). This was an unexpected finding. Less mature suture formation does not lead to more orthopedic effect, ie, parallel expansion of the maxilla. In the mixed dentition group, JL-JR expansion was limited in relation to the expansion achieved at the dental level. This indicates that beside the anchoring teeth themselves, the two maxillary halves might have bent and tipped buccally under heavy expansion forces (Figure 4).

CONCLUSIONS

RME showed several significant skeletal and dental effects on the dentofacial structures. After RME, maxilla moved forward; mandible rotated posteriorly; facial height increased; nasal, maxillary, and maxillary intercanine and first molar widths increased; and the upper molars tipped buccally in both the groups. Almost all these significant changes were stable at follow-up (T3).

When the overall (T1 − T3) differences were considered, the tipping of the anchorage teeth was greater and increases in the ANB angle were less in the mixed dentition group compared with the permanent dentition group ($P < .01$). Moreover, no statistically significant differences were found in the nasal cavity measurements.

Within the limits of this study, the results suggest that orthopedic effects of RME are not as great as expected at early ages, and it might be a better alternative to delay RME to early permanent dentition. Evaluation of slower activations (ie, one activation every other day) for RME in the mixed dentition should be a topic of future studies.

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