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Evaluation of the Rapid Maxillay Expansion Appliances Effects on Skeletal, Dental and Upper Airway with Posteroanterior Graphics

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Abstract: The aim of this study was to evaluate the dental and skeletal changes occurring during orthopedic Rapid Maxillary Expansion (RME) in transverse direction. Fifty subjects data is used for this purpose. Subjects are divided into two groups; RME applied expansion group and non-treated control group. RME is applied to 25 patients having bilateral crossbite and compared with a control group. Control group consists of subjects not having any transverse anomalies. Required expansion is achieved in 20+5 days and processed to 3 month retention. Pretreatment, posttreatment and 3rd month retention posteroanterior (PA) cephalometric graphy records are taken. Pretreatment, posttreatment and postretention PA cephalometric graphy records are evaluated within and between groups. In conclusion, statistically significant expansions were recorded in the transversal direction in the ZA-AZ, NC-CN, A6-6A, B6-6B and NC-O-CN parameters and it was determined that these results were more stable post-retention. As a result, following RME procedures; facial width, lower and upper first intermolar width and nasal cavity width is increased and post retention stability is recorded.

Key words: Rapid maxillary expansion, upper airway, maxillary narrowing

INTRODUCTION

The Rapid Maxillary Expansion (RME) technique is an orthodontic procedure first introduced by Angel in 1860 in the words opening the midpalatal suture (Wertz, 1970, Biederman, 1973; Bishara and Staley, 1987; Silva *et al*., 1991; Stockfisch, 1995). Both the dental and skeletal effects of RME have been comprehensively considered and reported by Haas (1970, 1980), Wertz (1970), Bishara and Staley (1985), Silva *et al*. (1991), Stockfisch (1995), Brin *et al*. (1996), Chang *et al*. (1997) and Baccetti *et al*. (2001, 2002) Chung and Font, 2004; Gautam *et al*., 2007). In addition to the likely skeletal and dental benefits of this procedure, opinions have also been expressed in the literature that it may be of use in the treatment of cases of temporary hearing loss and children with nocturnal enuresis (Laptok, 1981; Timms, 1990; Kurol *et al*., 1998).

Nasorespiratory function is generally held to have significant effects on dentofacial complex development (Bresolin *et al*., 1983; Keall and Vig, 1987; Jones and Suren 1994; Laine and Huggare, 1994; Ellingsen *et al*., 1995; Vig, 1998). Chronic nasal blockage in particular is reported to lead to oral respiration and it has been stated that the tongue and mandible change position as a result. It has been reported that if this arises in the active development period, a morphological structure known as adenoid face in which the vertical dimensions of the face increase, accompanied by a long and narrow maxilla and a vertical mandibular plane angle accompanied by labial insufficiency, will emerge (Bresolin *et al*., 1983; Warren and Hinton, 1986; Timms and Trenouth, 1988; Hartgerink and Vig, 1989; Jones and Suren 1994; Ceylan and Oktay, 1995; Vig, 1998).

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Arguments concerning the role of oral respiration, regarded as one of the causes of malocclusion, have attracted attention to RME in order to increase nasal respiration. The beneficial effects on nasal respiration of this procedure, frequently used in recent years in the treatment of skeletal maxillary narrowness, are still controversial (Uzel and Enacar, 1984; Staley *et al*., 1985; Warren *et al*., 1987). Today, this technique, frequently used in cases of skeletal maxillary narrowness, is still a cause for debate. Criticisms of the technique have concentrated on recurrence levels, it is leading to open closure, likely iatrogenic problems from sutural discomfort and its doubtful effects on nasal resistance (Bishara and Staley, 1987; Baykara, 1999).

In terms of the skeletal and dental effects of RME on the transverse dimension, many studies have shown increases in the width of the maxilla, nasal cavity and maxillary arch with use of a banded or a bonded expander (Baccetti *et al*., 2001; Basciftci *et al*., 2002; Chung and Font, 2004; Gautam *et al*., 2007).

The aim of this study was to determine the skeletal and dental effects of RME treatment administered to individuals in whom oral respiration predominated due to maxillary narrowness, using posterior-anterior cephalometric radiography.

MATERIALS AND METHODS

The subjects of this study consisted of patients applying to the Dicle University Dental Faculty Orthodontic Department for orthodontic treatment. Patients were divided into two groups: expansion (RME) and control group. The RME group consisted of 25 individuals, 21 female and 4 male, with bilateral diagoual closure and requiring maxillary expansion, aged between 12 and 19 with an average age of 14.9. The control group consisted of 25 individuals, 21 female and 4 male, with no maxillary narrowness in the transversal direction, aged between 12 and 19 with an average age of 14.5. In the expansion group, 75 posteroanterior radiograms were obtained pre-RME (T_1), immediately post-RME (20±5 days) (T_2) and 90 days after completion of RME (T_3). In the control group, 50 posteroanterior radiograms were obtained, initially (C1) and an average of 110 days subsequently (C2). Eleven of our cases had skeletal class 1 anomaly, two individuals had skeletal class 2 anomaly and 12 individuals had skeletal class 3 anomaly. During our research, RME apparatus alone was applied in the expansion group, while no fixed or mobile orthodontic procedure was performed in the control group.

In order for the Hyrax screw employed as an expansion device to be installed in an appropriate manner in each patient, permanent orthodontic bands were prepared on the upper first molars and upper first premolars, the upper canines were used in the absence of premolars. In the first day the RME apparatus was rotated until tension and/or pain was felt in the nasal region and the patients' parents were requested to turn it twice a day, ¼ in the evening and ¼ in the morning, over the following days. Patients parents were given training in activation and at the end of a 20±5 day period the desired expansion was achieved. In the experimental group, expansion was performed until the palatinal tubercle ends of the maxillary first molars approached the buccal tubercle ends of the mandibular first molars with the aim of extreme rectification. Following stabilisation of the screw, the apparatus was used over three months for retention purposes and after maximum expansion of the maxillary parts a reduction in likely recurrence was achieved. The points and measurements used for the study in the PA cephalometric films are provided below:

Skeletal Points Used In Posteroanterior Radiography

- **ZR Zygomatic: ZL Zygomatic:** The intersection of the zygomatico-frontal suture and the orbit (ZR: Right, ZL: Left zygomatic point).
- **ZA Zygomatic: AZ Zygomatic:** The centre of the origin of the zygomatic arch (AZ: Right, ZA: Left zygomatic point).

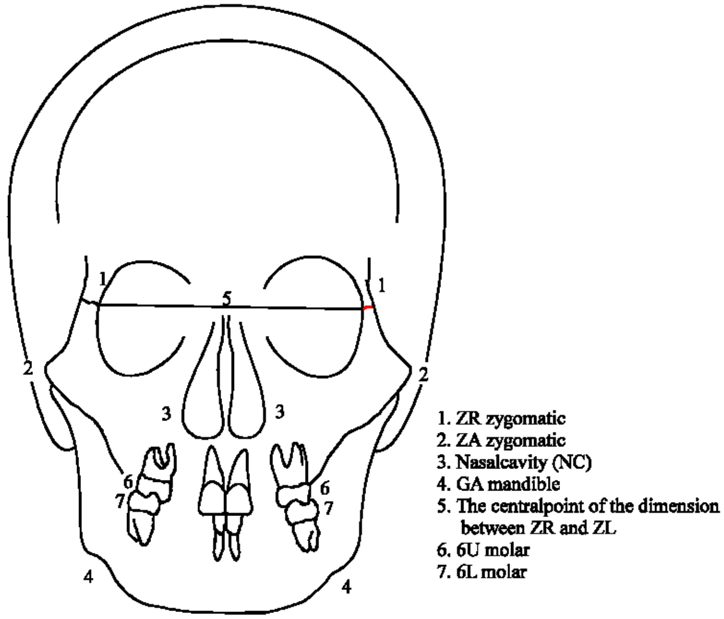

Fig. 1: Cephalometric points

- **Nasal Cavity (NC):** The outermost point in the widest region of the nasal cavity in cross-section (CN: Right, NA: Left nasal point).
- **GA Mandible: AG Mandible:** The lateral and inferior edge of the antegonial notch in frontal cephalometric films (GA: Right, AG: Left mandibular point).
- The central point of the dimension between ZR and ZL (Fig. 1) (Uzel and Enacar, 1984).

Dental Points

- 6U Molar: U6 Molar: The outermost point of the upper 1st molar buccal surfaces (6U: Right upper, U6: Left upper molar buccal point).
- **6L Molar: L6 Molar:** The outermost point of the lower 1st molar buccal surfaces (6L: Right lower, L6: Left lower molar outermost buccal point) (Fig. 1) (Uzel and Enacar, 1984).

Linear and angular measurements:

- **ZA-AZ:** This measurement gives facial width and it is determined by interzygomatic distance.
- **NC-CN:** This measurement gives nasal cavity floor width.
- **A6-6A:** This measurement gives the width between upper first molars (Fig. 2).
- **B6-6B:** This measurement gives the width between lower first molars (Fig. 2) (Uzel and Enacar, 1984).
- **ZGL (left side postural symmetry angle):** This measurement gives the left side postural symmetry angle.
- **ZGR (right side postural symmetry angle):** This measurement gives the right side postural symmetry angle.
- **NC-O-CN:** This measurement gives the angular width of the nasal cavity (Fig. 3) (Uzel and Enacar, 1984).

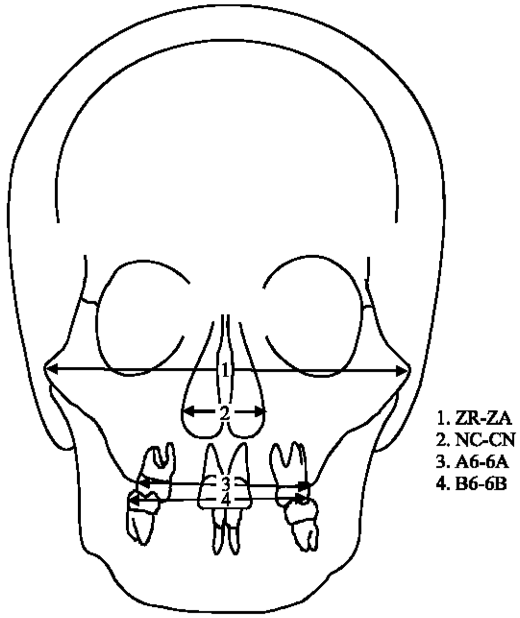

Fig. 2: Linear measurements

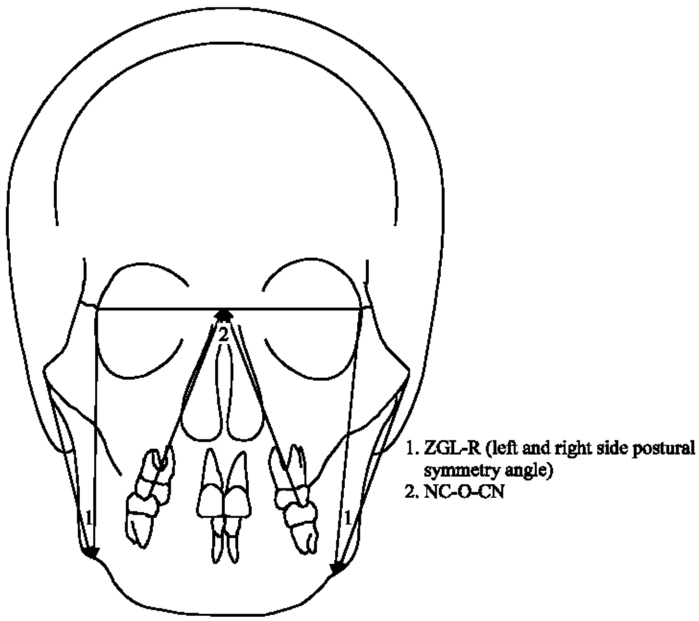

Fig. 3: Angular measurements

Statistical Method

Statistical significance of repeated measurements was tested using ANOVA (repeated measures), the paired sample t-test was used in comparisons within the treatment and control groups and the independent samples t-test in comparisons between the treatment and control groups.

RESULTS

Statistical significance in changes arising in all three periods in the treatment group as a result of this study and averages and standard deviation, are shown in Table 1 and 2.

In the RME group ZA-AZ, NC-CN and A6-6A measurements exhibited a significant rise, respectively of 2.06, 3.72 and 10.78 mm, in the pre-expansion/post-expansion period ($p<0.001$). NC-O-CN angle exhibited a statistically significant 2.86 degree, ($p<0.001$), increase in the pre-expansion/post-expansion period. On the other hand B6-6B measurement, ZGL and ZGR angles exhibited a statistically insignificant increase in the pre-expansion/post-expansion period (Table 3).

ZA-AZ, NC-CN and B6-6B measurements and ZGL and ZGR angles exhibited an insignificant increase in the post-expansion/post- retention period in the RME group. NC-O-CN angle a statistically insignificant 0.12 degree decrease in the post-expansion/post-retention period in the RME group (Table 3).

In the RME group ZA-AZ, NC-CN, A6-6A, B6-6B measurements and NC-O-CN angle a significant increase, respectively 1.80, 3.68, 10.78 and 1.18 mm and 1.19° in the pre-expansion/end of retention period (Table 3).

ZA-AZ measurement in the control group, there was a significant 0.22 rise, $p<0.05$, in the start of control to end of control period (Table 4).

NC-CN and A6-6A measurements a significant difference was determined between the groups in pre-expansion/start of control comparisons (Table 5 and 6).

Table 1: Statistical comparison of treatment group's changes in all three terms

Parameter	N	F	p-value
ZA-AZ	25	25.49	0.000***
NC-CN	25	27.55	0.000***
A6-6A	25	2110.32	0.000***
B6-6B	25	41.11	0.000***
ZGL	25	0.13	0.873ns
ZGR	25	0.20	0.813ns
NC-0-CN	25	119.81	0.000***

NS: Not Significant, Statistically Significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 2: Mean and standard deviations in treatment groups all three term measurements

		T_1		T_2		T_3	
Parameters	N	Mean	SD	Mean	SD	Mean	SD
ZA-AZ	25	134.32	7.69	136.38	7.635	136.12	8.312
NC-CN	25	29.84	3.66	33.56	2.64	33.52	2.38
A6-6A	25	56.00	3.32	66.78	3.87	66.78	3.87
B6-6B	25	61.56	3.61	62.20	4.24	62.74	3.70
ZGL	25	17.07	2.26	17.53	4.73	17.17	2.90
ZGR	25	17.16	1.95	17.41	3.04	17.15	2.94
NC-O-CN	25	32.08	3.34	34.94	3.31	34.82	34.05

Table 3: Comparison of changes between treatment T_1-T_2, T_1-T_3 and T_2-T_3 group

		T_1-T_2				T_1-T_3				T_2-T_3			
Parameters	N	Mean	SD	t	p	Mean	SD	t	p	Mean	SD	t	p
ZA-AZ	25	-2.06	1.68	-6.11	0.000***	-0.18	2.50	-3.60	0.001*	0.260	3.09	0.41	0.679ns
NC-CN	25	-3.72	2.50	-7.42	0.000***	-3.68	2.49	-7.36	0.000***	0.040	1.10	0.18	0.858ns
A6-6A	25	-10.78	1.17	-45.93	0.000***	-10.78	1.17	-45.93	0.000***	0.00	0.00	-	-
B6-6B	25	-0.64	1.72	-1.87	0.073ns	-1.18	0.64	-9.24	0.000***	0.054	1.81	1.48	0.151ns
ZGL	25	-0.46	4.33	-0.53	0.060ns	-0.10	2.70	-0.18	0.833ns	0.360	4.50	0.39	0.693ns
ZGR	25	-0.25	2.97	-0.42	0.676ns	0.80	2.70	0.01	0.988ns	0.260	2.01	0.64	0.524ns
NC-0-CN	25	-2.86	0.90	-15.76	0.000***	-2.74	1.19	-11.50	0.000***	0.120	0.89	0.67	0.508ns

NS: Not Significant, Statistically Significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 4: Comparison of mean and standard deviations of both terms in control group and inter-term changes

		C1		C2		C1-C2	
Parameters	N	Mean	SD	Mean	SD	T	p-value
ZA-AZ	25	136.24	4.88	136.46	4.96	-2.68	0.013*
NC-CN	25	33.18	4.21	33.76	3.35	-1.43	0.105ns
A6-6A	25	65.30	4.00	65.30	4.00	-1.00	0.327ns
B6-6B	25	61.90	3.94	61.96	4.03	-1.59	0.559ns
ZGL	25	17.04	2.64	17.38	2.18	-1.94	0.064ns
ZGR	25	17.20	1.96	17.32	1.87	-1.36	0.185ns
NC-0-CN	25	34.14	4.32	33.75	3.71	1.18	0.248 ns

NS: Not Significant, Statistically Significant, *: p<0.05, **: p<0.01, ***: p<0.001

Table 5: Comparison between treatment T1 group and control C1 group

Parameters	N	t	p-value
ZA-AZ	25	-1.05	0.297ns
NC-CN	25	-2.99	0.004**
A6-6A	25	-8.93	0.000***
B6-6B	25	-0.31	0.752ns
ZGL	25	0.04	0.963ns
ZGR	25	-0.07	0.943ns
NC-0-CN	25	-1.88	0.065ns

NS: Not Significant, Statistically Significant, *: p<0.05, **: p<0.01, ***: p<0.001

Table 6: Comparison between treatment T3 group and control C2 group

Parameters	N	t	p-value
ZA-AZ	25	-0.17	0.861ns
NC-CN	25	-0.29	0.772ns
A6-6A	25	1.32	0.190ns
B6-6B	25	0.71	0.476ns
ZGL	25	-0.28	0.776ns
ZGR	25	-0.24	0.811ns
NC-0-CN	25	1.11	0.273ns

NS: Not Significant, Statistically Significant, *: p<0.05, **: p<0.01, ***: p<0.001

DISCUSSION

In this study, the effects of the RME apparatus on the dentofacial system and upper respiratory tract were investigated comparatively by the taking of posteroanterior cephalometric films pre-expansion, post-expansion and at the end of the 3-month retention period in the RME group and initially and after an average of 110 days in the control group. In this study cases with bilateral diagonal closure were specially selected for the experimental group. The control group consisted of cases exhibiting no maxillary narrowness. The effects of banded RME were investigated in a multi-directional comparison with the control group.

Researches show that oral respiration is one of the main etiological factors in maxillary narrowness (Miller *et al*., 1984; Gross *et al*., 1994; Baykara, 1999). RME treatment brings about an amelioration in the maxillary arch structure, improves nasal respiration over oral respiration and also improves physical development and general health (Haas, 1970; Laptok, 1981; Bishara and Staley, 1987; Chate, 1994; Asanza *et al*., 1997; Chang *et al*., 1997; Kurol *et al*., 1998; Baykara, 1999).

Wertz (1970) reported that there was no significant difference between the sexes in terms of RME effects. No gender difference was also observed in other studies investigating the effects of RME (Bishara and Staley, 1987; Warren *et al*., 1987; Akkaya and Hizlan, 1997). No gender distinction was therefore made in our study.

Several researchers have reported significant post-RME increases in nasal cavity width of 1.4-3.5 mm, parallel to present findings (3.68 mm) (Haas, 1970; Biederman, 1973; Timms, 1980; Bishara and Staley, 1987; Silva *et al*., 1995; Baykara, 1999; Memikoglu and İşeri, 1999; Chung and Font, 2004). Memikoglu and İşeri (1999) reported a significant, 1.65 mm, increase in nasal cavity width post-bonded RME. Akkaya and Hizlan (1997), Silva *et al*. (1995) and Baykara (1999) reported increases in nasal cavity width compatible with our findings. The significant increase in the nasal width might support the theory that maxillary expansion increases air flow and improves nasal breathing (Basciftci *et al*., 2002; Chung and Font, 2004)

Akkaya and Hizlan (1997) and Memikoglu and İşeri (1999) determined a post-RME increase in interzygomatic width similar to our own findings, but reported that this increase was insignificant. Our results reveal an significant increase (2.06 mm) in facial width in agreement with the findings of Timms (1980) and Chung and Font (2004).This increase is preserved on post-retention (1.8 mm).

In present study, we found an increase in maxillary intermolar width (A6-6A) significantly with 10.78 mm. (Haas, 1970; Cotton, 1978; Brosh *et al*., 1998; Asanza *et al*., 1997; Memikoglu and Iseri, 1999; Chung and Font, 2004).

The literature contains many studies reporting increased mandibular intermolar width post-RME, compatible with our findings (Haas, 1980; Timms, 1980). Cotton (1978) noted that the mandibular arch exhibited an expansion linked to changing occlusion and muscle balance post-RME. But in a study investigating the effects of RME on maxillary and mandibular canine and molar width in 38 patients aged between 6 and 13, Gryson (1977) reported either no increase or else one above 1 mm in mandibular intermolar width.

In a study in which he compared the effects of banded and bonded RME, Baykara (1999) measured nasal cavity width in angular terms and obtained, in agreement with present findings (1.97°), a statistically significant increase of 1.25°. Memikoglu and İşeri (1999) measured post-RME nasal cavity width in angular terms in 14 patients and determined an insignificant, 1.13°, increase.

The right-side postural symmetry angle being smaller than that on the left shows that the right sides of the individuals constituting our cases were narrower than the left.

As stated above, statistically insignificant decreases took place in postural symmetry angles. But the fact that this angle attained the same value on both sides at the end of retention suggested that there was less skeletal response on the left side, which was less in need of expansion and that RME may have positive effects on postural symmetry.

The following conclusions were reached concerning the skeletal and dental effects of RME treatment in this study of 50 patients using cephalometric analysis:

- Sutural opening was achieved in all cases as a result of RME and it was determined from occlusal images that sutural bone growth was re-established at the end of 3-month retention.
- Significant increases in facial width, width between upper and lower 1st molars and nasal cavity width were determined post-RME and it was determined that these increases remained stable at the end of retention.
- Cases in the RME group stated, subjectively, that they were able to breathe through the nose more comfortably after RME.

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