Effects of a bonded rapid maxillary expansion appliance during orthodontic treatment

T. Ufuk Toygar Memikoglu, DDS, PhD; Haluk Işeri, DDS, PhD

Abstract: The aim of this prospective study was to evaluate changes in the transverse plane following use of an acrylic bonded rapid maxillary expansion (RME) appliance in growing individuals during the active phase of treatment. The sample comprised 14 consecutively treated orthodontic patients (11 girls, 3 boys) who required the use of an RME device on the basis of their individual treatment plans. The mean patient age at the start of treatment was 12.8 years, and the mean overall treatment time was 3.08 years. Seven posteroanterior cephalometric and two dental cast measurements were assessed. Repeated measure analysis of variance and Duncan's multiple range test were used to assess treatment changes. Lower nasal and maxillary base widths and angles, and upper intermolar width increased significantly during RME treatment. Upper intermolar and intercanine widths measured from the dental casts also increased significantly. Except for upper intercanine width, all measurements remained constant at the end of orthodontic treatment. The results of this study suggest that dentoskeletal changes in the transverse dimension following the use of an acrylic bonded RME are maintained satisfactorily at the end of fixed appliance therapy.

Key Words: Maxillary expansion, Bonded RME appliance, Transverse dimension

Rapid maxillary expansion (RME) is an orthodontic procedure routinely used when the constricted maxilla and upper dental arch demand orthopedic widening.[1-6] Numerous RME appliances have been developed for this purpose. Conventional RME appliances widen the maxillary arch in the transverse direction, mainly by separating the maxillary halves, but also by moving the posterior teeth and alveolar processes buccally.[1] However, tipping and extrusion of the maxillary posterior teeth and alveolar bending usually result in posterior rotation of the mandible.[2,3,5,7] Additionally, long-term evaluation of cases treated using conventional maxillary expansion appliances indicates that they have a tendency to relapse due to the resistance to deformation from surrounding structures.[8,9] Velazquez et al.[10] observed no vertical or anteroposterior skeletal differences with the conventional Haas-type RME device 3 years after initiating RME treatment, but they did not investigate transverse skeletal responses. Sarnas et al.[9] presented a case treated using conventional RME. The patient was followed for 10 years with metallic implants and roentgen stereometry, and extensive relapse was noted at the end of the observation period.

Bonded RME appliances with full occlusal coverage have been reported to have certain advantages over conventional RME appliances.[11-20] Recent studies have stated that bonded RME appliances may not only control the vertical dimension, but may also expand the maxillary halves in a more bodily fashion.[6,13-15,18,20] Relevant studies also suggest that the type of movement observed with bonded RME appliances may be due to the additional surface coverage, which limits unwanted tipping and rotation of teeth by increasing rigidity.[6,13,16,18,20] The evaluation of an individual case treated with a rigid acrylic bonded RME device has shown no evident relapse 2 years after removal of the appliance.[19] Taking these short-term advantages into consideration, we hypothesized that the use of rigid acrylic bonded RME appliances in growing patients who have posterior crossbite may reduce the risk of relapse. Therefore, the aim of this prospective study was to evaluate the results of acrylic bonded RME

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therapy in the transverse dimension in growing individuals during the active phase of treatment.

Materials and methods

The sample comprised 14 consecutively treated orthodontic patients (11 girls and 3 boys) who required the use of an RME device on the basis of their individual treatment plans. The mean patient age was 12.8 years (range 11.5 to 13.1 years) at the start of treatment (Table 1).

Selection criteria for the study group were as follows:

- All patients had bilateral crossbite.
- None had craniofacial anomalies, such as cleft lip and palate.
- All teeth were present.
- All patients were between MP_3 and MP_{3cap} maturation stages at the beginning of treatment.[21]
- Good quality cephalograms (teeth in centric occlusion, easily recognized hard tissue and dental structures) and dental casts were available for all treatment stages.

Four patients had a Class I skeletal pattern, five were Class II, and five were Class III. All patients were treated initially with an acrylic bonded RME appliance, followed by fixed appliance therapy. Four patients needed to have four first premolars extracted after RME treatment, and seven patients wore high-pull headgear during fixed orthodontic therapy. After the insertion of .018" slot standard edgewise appliances, leveling was begun using .016" round stainless steel archwires. Nitinol archwires were not used, and no special precautions were taken other than using thick, wide archwires. During the finishing phase of treatment, clinically coordinated upper and lower rectangular archwires (.017"x.022") were used. Mean overall treatment time was 3.08 years. At the end of fixed appliance therapy, all patients wore Hawley retainers.

Table 1
Distribution of age

	Before RME treatment x ± Sx	After RME treatment x ± Sx	End of treatment x ± Sx
Age*	12.80 ± 1.02	13.12 ± 1.09	15.88 ± 1.28

x= mean Sx= standard error of the mean
*(Years.months)

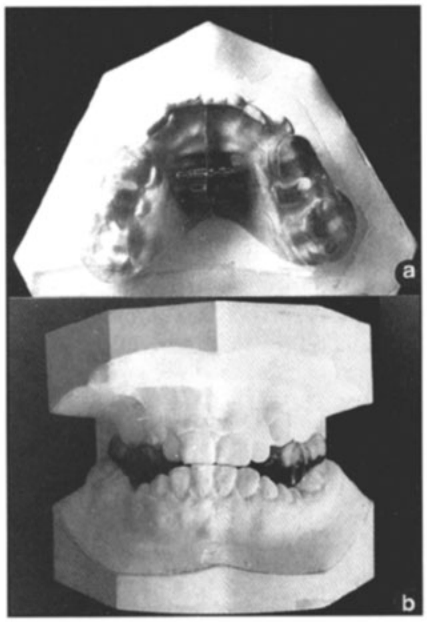

Figure 1A-B
Rigid acrylic bonded RME appliance

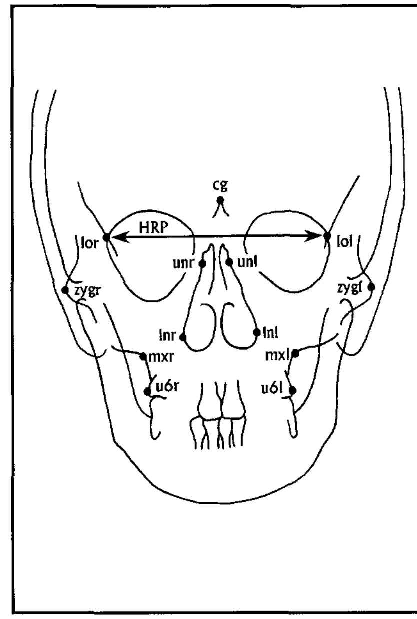

Figure 2
Reference points and planes

RME treatment

The design of the acrylic bonded RME appliance used in this study has been described by Memikoglu and Iseri[19] (Figure 1). A maxi-skeleton jackscrew was embedded in acrylic between the first premolars as close as possible to the palate, with the resin covering the occlusal and labial surfaces of the maxillary posterior permanent teeth. The resin was trimmed thin enough to preserve freeway space while allowing maximum occlusal contact bilaterally. After bonding of the RME appliance, the patient's parents were instructed to activate it by turning the screw one half-turn in the morning and another half-turn in the evening. Each quarter-turn of the screw produced 0.2 mm of expansion. The activation period lasted 2 to 3 weeks, depending on the severity of the maxillary constriction. After fixation of the screw, the RME device was removed and the same appliance was used as a removable retention plate for 6 months in order to allow the tissues to reorganize in their new relationship. The appliance was worn full-time during this period.

Records

For each patient, the first set of records (PA cephalometric, hand-and-wrist, and occlusal films; and dental casts) was obtained before the beginning of treatment, the second set was gathered when the RME appliance was removed, and the third set (PA cephalometric and hand-and-wrist films and dental casts) was obtained at the end of active treatment. For the PA film, the subject was positioned facing the film, with his or her head in the cephalostat and

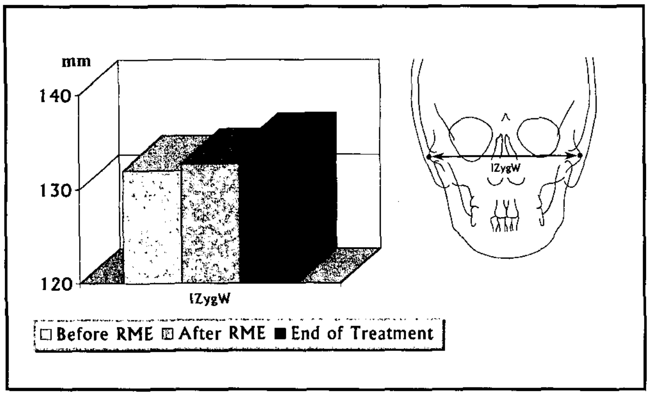

Figure 3
Overall treatment changes for interzygomatic width (IZygW), the distance between zygr and zygl

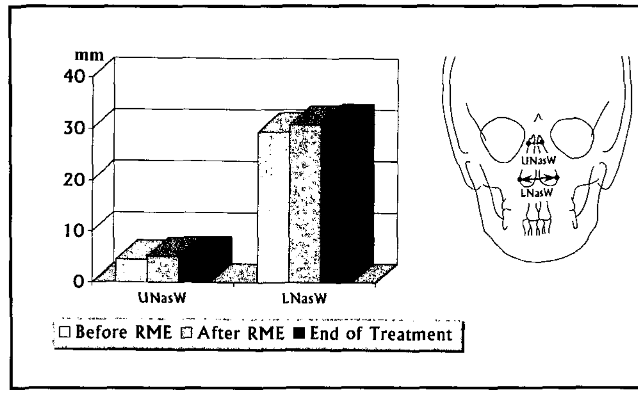

Figure 4
Overall treatment changes for upper nasal width (UNasW), the distance between unr and unl, and lower nasal width (LNasW), the distance between lnr and lnl

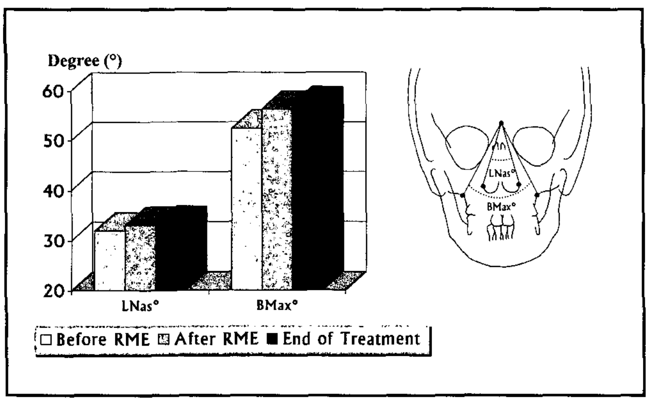

Figure 5
Overall treatment changes for lower nasal angle (LNas°), the angle between cg-lnr and cg-lnl, and basal maxillary angle (BMax°), the angle between cg-mxr and cg-mxl

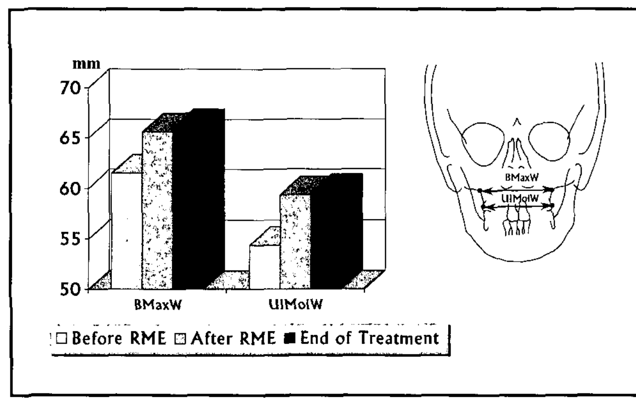

Figure 6
Overall treatment changes for basal maxillary width (BMaxW), the distance between mxr and mxl, and upper intermolar width (UIMolW), the distance between u6r and u6l

Frankfort plane parallel to the floor. To standardize magnification, the film was placed 15 cm away from the ear rods.

Measurements

Reference points and planes used in this study were as follows (Figure 2):

Crista galli (cg): Geometric center of crista galli

Right and left latero-orbital points (lor-lol): Intersection of the inferior border of the greater wing of the sphenoid bone and lateral orbital margin

Right and left zygomatic points (zygr-zygl): Lateralmost aspect of the zygomatic arch

Right and left upper nasal points (unr-unl): Innermost point on the nasal apertura taken parallel to the HRP

Right and left lower nasal points (lnr-lnl): Lateralmost point on the anterior nasal apertures taken parallel to the HRP

Right and left maxillary points (mxr-mxl): Deepest point on the curvature of the malar process of the maxilla

Right and left upper first molar points (u6r-u6l): Midpoint on the buccal surface of the permanent maxillary first molar crown

Horizontal reference plane (HRP): Plane constructed between left and right latero-orbital points (lor and lol)

A total of seven cephalometric and two dental cast measurements were assessed in the study. Anatomic landmarks were identified and digitization was performed to calculate linear and angular measurements for the posteroanterior cephalometric measurements (Figures 3 to 6). Direct measurements were carried out from the dental casts for dental cast measurements by the use of a gauge caliber (Figure 7).

Statistical methods

Intraclass correlation coefficients were performed to assess the reliability of landmark identification, digitization, and calculation of measurements.

Repeated measure analysis of variance and Duncan's multiple range test were used to evaluate the treatment changes respectively. Minitab for Windows Statistical Package was used for this purpose.

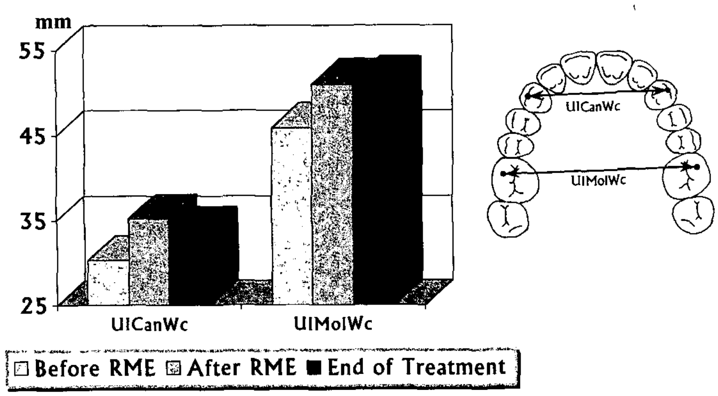

Figure 7
Overall treatment changes for upper intercanine width (UICanWc), the distance between cusp tips of the upper canines, and upper intermolar width (UIMolWc), the distance between the mesiobuccal cusp tips of the upper first molars

Table 2
Reliability of the measurements (n=14)

Measurements	Coefficient of reliability
IzygW	0.9877
UNasW	0.9846
LNasW	0.9927
LNas°	0.9899
BMax°	0.9889
BmaxW	0.9876
UIMolW	0.9366
UICanWc	0.9991
UIMolWc	0.9911

Results

Table 1 describes the age distribution and treatment periods of the patients.

All procedures for measurement calculation (landmark identification, digitization) were repeated on all 14 subjects. Reliability of all measurements was within clinically acceptable limits (0.93 to 0.99, Table 2).

Table 3 shows descriptive statistical data for all variables used, before and after RME treatment and after completion of the orthodontic treatment. Table 3 also shows the results of the repeated measure analysis of variance and Duncan's multiple range test, and Figures 3 to 7 represent the overall expansion and relapse for all measurements in the study. The following findings were observed:

During RME treatment (1-2), lower nasal width (LNasW), basal maxillary width and angle (BMaxW and BMax°), and upper intermolar width (UIMolW) increased significantly ($p<0.01$). Although statistically insignificant, lower nasal angle (LNas°) also increased. Upper intermolar and upper intercanine widths (UIMolWc and UICanWc) from the dental casts also increased significantly during RME ($p<0.01$).

Before fixed appliance therapy and after orthodontic treatment (2-3), all measurements except upper intercanine width remained constant.

Overall treatment changes (1-3) included significant ($p<0.01$) increases in lower nasal width (LNasW), basal maxillary width and angle (BMaxW and BMax°), upper intermolar width (UIMolW), and upper intermolar and upper intercanine widths (UIMolWc and UICanWc), as measured from the dental casts.

Discussion

A number of researchers have considered the stability of conventional rapid maxillary expansion therapies. Their studies suggest that the degree of relapse might be related to such factors as age of patient,[5,22,23] rate of expansion,[8,24] design of the device,[17,20,25] length of the retention phase,[10] severity of the maxillary collapse and response of the midpalatal suture and surrounding structures of the maxilla,[8,26-28] cooperation during the retention period,[29] and adaptation of the soft tissues to the new positions.[30]

Haas[3] reported on a series of patients who were followed with PA films for 1 year after expansion therapy. He noted that increases in nasal cavity and apical base widths of the maxilla remained stable. In a follow-up study 5 years later,[31] none of the patients showed any relapse in nasal cavity or apical base width. In his 1968 study, Timms[26] showed, contrary to Haas, that a significant amount of relapse occurred. McNamara[17] stated that the differences between the studies of Timms and Haas might be due to variations in appliance design, as Timms used a nonrigid expansion appliance. Haas[1] believed that more bodily movement and less dental tipping were produced when acrylic palatal coverage was added to support the appliance, thus forces are generated not only against the teeth but also against the underlying soft and hard palatal tissues.

According to the relevant literature, the more rigid type of acrylic bonded RME appliance has some advantages over conventional designs.[11-20] Studies have shown that the treatment effect with bonded RME therapy is skeletal rather than dentoalveolar, and more parallel movement of the anchor teeth is possible due to the increased surface coverage. Additionally, the coverage of the occlusal surfaces eliminates occlusal contacts during expansion of the maxillary segments. On the other hand, Mossaz-Joelson and Mossaz[32] found that skeletal and dental response to slow maxillary expansion was identical in banded and bonded groups. As these effects are related to the short-term results of bonded RME appliances and no consequences have been reported during the active phase of treatment, the present study was designed to evaluate the results of acrylic bonded RME appliance therapy on the transverse dimension at the end of orthodontic treatment.

The coefficient of reliability for all measurements was found to be within clinically acceptable limits (0.93-0.99, Table 2). However, the coefficient of reliability for the upper intermolar width was relatively low (0.93). Because of this, the same parameter was also measured on dental casts, and it was found to be high (0.99).

Many investigators agree that RME treatment can be accomplished in both adolescents and adults.[5,8,22,33,34] The literature argues that the age and the maturation level of the individual are important factors when considering the effect of RME on craniofacial structures. RME treatment is more effective in adolescents than in adults. With advancing maturity, the rigidity of the skeletal components limits the amount of expansion and the long-term stability.[5,22,24] Therefore, care was taken to select patients who were in the pubertal growth phase (MP_3 –MP_{3cap}), with a mean chronological age of 12.80±1.02 years at the start of treatment (Table 1).

Table 3
Descriptive statistical data and the results of repeated measure analysis of variance and Duncan's multiple range test

	Before RME treatment (1) x ± Sx	After RME treatment (2) x ± Sx	End of treatment (3) x ± Sx	test	1-2	1-3	2-3
Postero-anterior film analysis (Figures 3-6)							
IZygW	132.04 ± 1.42	132.73 ± 1.70	134.35 ± 1.48	ns			
UNasW	4.83 ± 0.42	5.05 ± 0.47	5.26 ± 0.35	ns			
LNasW	29.44 ± 0.67	30.88 ± 0.66	31.09 ± 0.76	**	**	**	
LNas°	31.87 ± 1.06	33.00 ± 1.09	33.08 ± 1.12	ns			
BMax°	52.45 ± 0.56	56.28 ± 0.99	57.10 ± 1.40	**	**	**	
BMaxW	61.50 ± 1.05	65.62 ± 1.11	66.07 ± 0.98	**	**	**	
UIMolW	54.34 ± 0.72	59.36 ± 1.14	59.56 ± 0.95	**	**	**	
Cast analysis (Figure 7)							
UICanWc	30.27 ± 0.64	35.18 ± 0.66	33.69 ± 0.41	**	**	**	
UIMolWc	45.89 ± 1.04	51.00 ± 1.12	51.31 ± 1.03	**	**	**	

ns=not significant, * $p<0.05$, ** $p<0.01$
x= mean, Sx= standard error of the mean

Dentoskeletal changes in the transverse dimension

Changes obtained by the rigid acrylic bonded RME device were as follows (Table 3, Figures 3 to 7): Significant amounts of linear and angular transverse increases were observed in the lower nasal cavity, maxillary base, and dentoalveolar structures. As in previous RME studies,[2,3,5,19,20,23,33,35] our findings indicate that the greatest widening occurred in the dentoalveolar area, and the widening effect of the bonding device gradually decreased through the upper structures in a triangular pattern. The mean increase in maxillary base width was more than one-half the amount of intermolar expansion (Table 3). On the other hand, in his metallic implant studies, Krebs[35] found that the amount of sutural opening was equal to or less than one-half the amount of the dental arch expansion.

Fixed orthodontic therapy produced results such as those in Table 3 and Figures 3 to 7: Three years after the initiation of orthodontic treatment, all measurements except upper intercanine width were stable. We observed no statistically significant changes between the final records of bonded RME treatment and those at the end of fixed appliance therapy. During fixed appliance therapy, the maintenance of or slight increase in the dentoalveolar expansion was expected due to the use of thick, wide archwires. The maintenance of dentoalveolar expansion during this period would be due to the strength of the appliance rather than any intrinsic qualities of the bonded expander. The findings of the present study also revealed no relapse in maxillary base area or lower nasal width. These findings showed that the rigid acrylic bonded RME appliance used in this study might be more effective when the maxillary base area is the main concern. Although statistically insignificant, it should be noted that UICanWc decreased during fixed therapy. This finding could have been the result of expansion of the upper canines, which were not in crossbite at the time of expansion and returned to their original positions during fixed treatment.

Previous studies explained the short-term advantages of bonded RME therapy.[6,13,16,18,20] The present study suggests that the dentoskeletal expansion achieved with bonded RME therapy can be maintained during orthodontic treatment. In addition to the use of thick, wide archwires during fixed appliance therapy, the rigid design of the device, the contribution of the patient's maturation level, and the duration of the RME retention phase may contribute to the stability. Last but not least, the findings of this study may be promising for RME concerning prevention of relapse over the long term.

Conclusion

The results suggest that dentoskeletal changes achieved with an acrylic bonded RME appliance were maintained satisfactorily in the transverse dimension at the end of fixed appliance therapy in growing subjects. Nevertheless, further studies, especially long-term studies, are needed.

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