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COMPARISON of DENTOFACIAL CHANGES with RIGID ACRYLIC BONDED and HAAS TYPE BANDED RAPID MAXILLARY EXPANSION DEVICES

T. Ufuk Toygar MEMİKOĞLU*,
Haluk İŞERİ,**
Melike E. UYSAL***

SUMMARY: The aim of this study was to describe and compare the dentofacial changes obtained with the Haas type banded and rigid acrylic bonded RME therapies. Lateral and posteroanterior radiographs, and dental casts of 30 growing children who had unilateral or bilateral posterior crossbite were analysed. The study groups consisted of 21 cases treated with acrylic bonded and 9 cases treated with Haas type banded RME appliances. Results revealed that lower nasal width, basal maxillary width and intermolar width were increased in both groups. Increase in the inclination of the upper molars in the transversal direction was more in the banded group compared to the bonded group ($p<0.05$) Overbite was markedly reduced in the banded group (-2.51 mm), while slightly decreased in the bonded group (-0.61 mm), and the difference between the two groups was statistically significant ($p<0.01$). The findings of this study suggest that the rigid acrylic bonded RME appliance may be an acceptable alternative compared to the conventional banded RME appliance, especially in cases with insufficient overbite.

Key Words: Maxillary expansion, lateral and posteroanterior cephalographs.

ÖZET: RİJİT AKRİLİK BONDED VE HAAS TİP BANTLI RAPİD MAKSİLLER EKSPANSİYON AYGITLARI İLE DENTOFASİYAL YAPILARDAKİ DEĞİŞİKLİKLERİN KARŞILAŞTIRMASI. *Bu çalışmanın amacı, Haas tip bantlı Rapid Maksiller Ekspansiyon (RME) ve rijit akrilik bonded RME tedavileri sonucunda elde edilen dentofasiyal değişiklikleri değerlendirmek ve bu sonuçları karşılaştırmaktır. Araştırma materyalini unilateral veya bilateral çapraz kapanışa sahip 30 büyümekte olan bireyin lateral, posteroanterior filmleri ve ortodontik modelleri oluşturmuştur. 21 kişiden oluşan bonded RME ve 9 kişiden oluşan bantlı RME tedavisi gören 2 grup hasta, çalışma gruplarını oluşturmuştur. Elde edilen sonuçlara göre alt nazal genişlik, bazal maksiller genişlik ve üst intermolar genişlik her iki grupta da artmıştır. Transversal yönde üst molarların eğimindeki artış bantlı grupta bonded gruba kıyasla daha fazladır (p<0.05). Overbite bantlı grupta belirgin bir şekilde azalırken (-2.51 mm), bonded gruptaki azalma daha düşüktür (-0.61 mm) ve gruplar arasındaki fark istatistiksel olarak önemli bulunmuştur (p<0.01). Sonuç olarak bu çalışmada, özellikle yetersiz overbite'a sahip bireylerde rijit akrilik bonded RME aygıtı konvansiyonel bantlı RME apareyine alternatif olarak kabul edilebilir bulunmuştur.*

Anahtar Kelimeler: *Maksiller genişletme, lateral ve postero anterior filmler.*

* *Research Assistant, Department of Orthodontics, School of Dentistry, University of Ankara, Turkey.*
** *Professor, Department of Orthodontics, School of Dentistry, University of Ankara, Turkey.*
*** *Private practice, Aydın, Turkey.*

INTRODUCTION

Rapid maxillary expansion (RME) procedure has been used over the past century (2). Haas (8-10), Isaacson and Murphy (15) and Wertz (31) advocated RME for the narrow arches. RME has been shown to be a valuable aid in the orthodontic treatment of young patients exhibiting maxillary collapse, pseudo Class III malocclusion, rhinologic and respiratory ailments (5, 7, 10, 11, 31) and cleft lip and palate (15).

Numerous fixed appliances such as Haas, Hyrax and Minne type banded appliances are widely used by the clinicians. Conventional RME appliances widen the upper arch in the transversal direction mainly by the separation of the two maxillary halves and by buccal movement of the posterior teeth, and alveolar processes. However, tipping and extrusion of maxillary posterior teeth, along with alveolar bending usually result in a posterior rotation of the mandible. Thus, the procedure tends to open the bite, and causes an undesired vertical hyperdivergence especially in long face cases with a short posterior facial height (1, 6, 7, 10, 31). Additionally, long term evaluation of cases who were treated by these conventional methods of maxillary expansion have been shown to have a relapse tendency (5, 21, 26).

Bonded RME appliances with full occlusal coverage have been reported to have certain advantages over conventional RME appliances (14, 19, 20, 27, 29). In 1987, Alpern and Yurosko (1) described the successful use of a cemented palatal expansion appliance with a bite plane in eighty-two patients under the age of 25 and in forty-three adult patients between age 20 to 43. They reported that the covering of the occlusal surfaces eliminated occlusal interferences during lateral displacement of the maxillary segments. In 1989, Mossaz-Joelson and Mossaz (22) found that the skeletal and dental response to slow maxillary expansion was identical in banded and bonded groups. In 1989, Sarver and Johnston (25) stated that the bonded rapid palatal appliance would increase the rigidity by limiting unwanted tipping and rotation of teeth due to the increased surface coverage on the teeth. However, no detailed statistical data is available to evaluate the effects of the rigid acrylic bonded RME technique on dentoalveolar and skeletal structures. Hence, it was the aim of this study to statistically compare the three dimensional dentofacial changes obtained by the bonded and banded RME appliances.

MATERIALS AND METHODS

The study was performed on 30 growing children (23 girls, 7 boys), presenting either unilateral or bilateral posterior crossbites. Twenty-one cases were treated with the occlusally bonded RME appliance and 9 cases were treated with the conventional Haas type banded RME appliance.

All patients were in the pubertal spurt phase (12) (Table I). The age distribution of the study sample in shown in Table II.

The design of the bonded RME appliance was previously described by Memikoğlu and İşeri (20) (Fig. 1). In the banded group, conventional Haas type RME appliances were used.

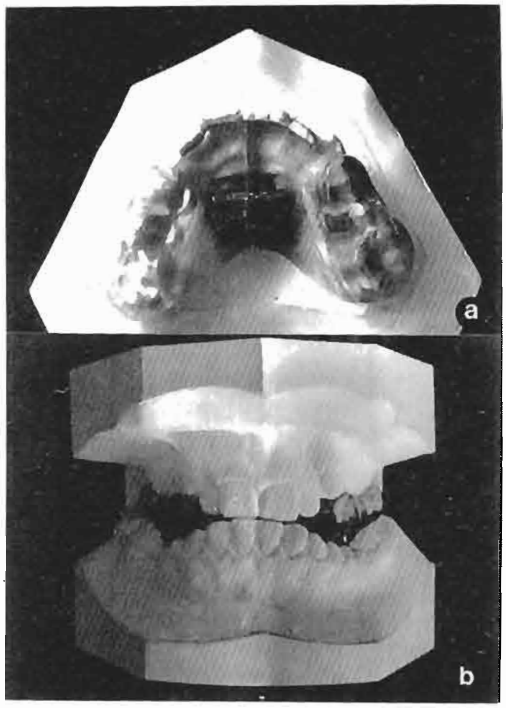

Fig 1. Bonded RME appliance.

Table I: Survey of the sample according to maturation stage.

Maturation stage	BONDED RME n=21	BANDED RME n=9
MP3=	5	1
S	3	2
MP3cap	10	1
$DP3_U$	2	3
$PP3_U$	1	2

Table II: Distribution of age.

	Beginning of treatment	End of treatment	Duration of treatment
	$\bar{X}$±SD	$\bar{X}$±SD	$\bar{D}$±SD
BONDED RME	12.81±1.06	13.21±1.19	0.40±0.27
BANDED RME	13.16±1.39	13.39±1.38	0.24±0.18

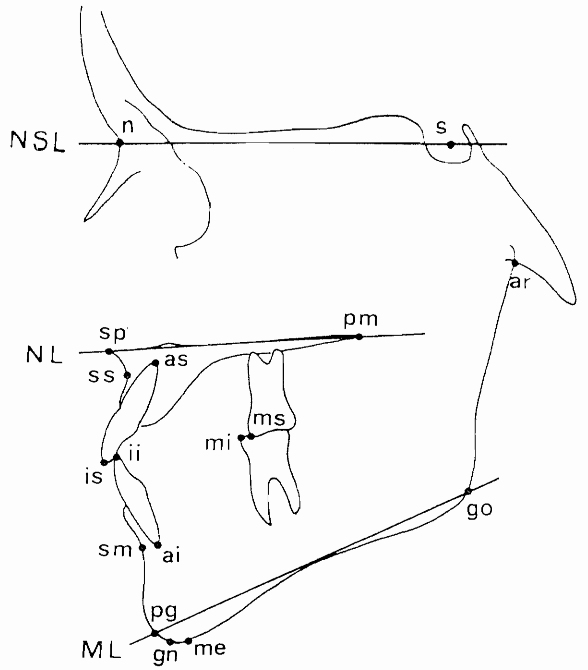

Fig. 2: Reference points and planes used in the lateral cephalometric films

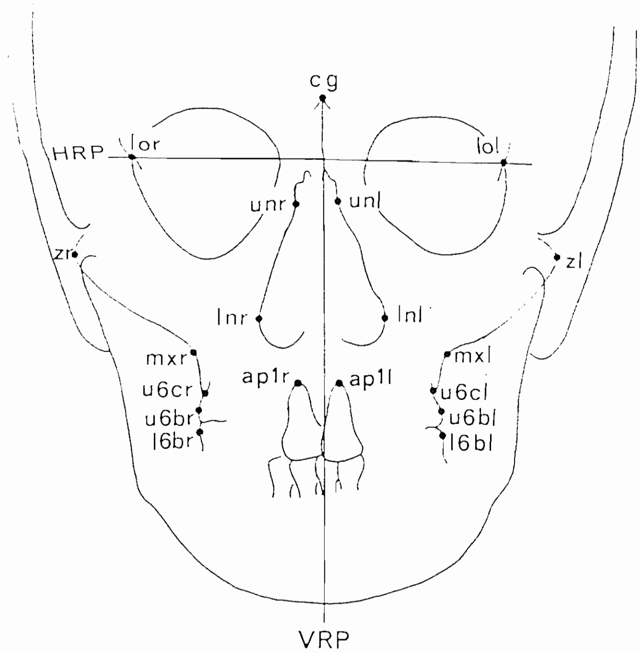

Fig. 3: Reference points and planes used in the PA films.

Records

The lateral, postero-anterior (PA) and occlusal films, and dental casts were obtained before and after RME treatment. The lateral and PA cephalometric films were recorded in a Siemens Orthoceph 10 cephalometer. The profile radiographs were recorded with fixed focus to mid-sagittal plane and mid-sagittal plane to film distances of 150 and 12.5 cm respectively. For the PA films, the subjects were positioned with the face turned to the film. The head was positioned in the cephalostat with the Frankfort plane parallel to the floor. To standardise the magnification during the recording procedure, the ear rods were placed 15 cm away from the film. The lateral and PA films of the patients were obtained before treatment and after the period of stabilization at the time appliance was removed in the treatment groups. However, in the banded group the second records were obtained after the last activation in 2 cases.

The reference points and lines utilised on lateral cephalometric films had been previously described by Arat and İşeri (3) (Fig. 2). Reference points and lines, and the measurements performed on PA cephalometric films are shown in Figure 3 and described in Table III.

Marking upper first molars on PA films is a difficult procedure. Thus, dental casts were used to evaluate the changes in the maxillary first molars inclination in the transversal direction in the bonded group. However, due to the retrospective design of this study while forming our conventional banded RME group, only PA films could be used because of the inadequate quality of the dental casts. Fortunately, as the molar bands could clearly be seen in the PA films, dental casts would not bring a significant advantage for the banded RME group.

On the PA films, upper and lower tips of the images on the right and left upper first molars bands were marked in the banded group to form the reference line to assess molar inclination (Fig. 3).

The dental casts were trimmed parallel to the upper occlusal plane, up to the distal surface of the right and left upper molars. The photographs were taken in a standard condition with a copy stand. Then, 2.5 times magnified prints of the beginning and end of treatment casts were produced for all of the bonded RME patients in order to be able to locate the points more clearly. The upper first molar points were marked and digitised on the magnified cast prints (Fig. 4a, b).

Statistical methods

Reference points were digitised on a Houston Hipad digitizer with a resolution of 0.125 mm. Paired and student t-

Table III: Description of reference planes and measurements used in postero-anterior cephalometric radiographs.

Reference Planes:	
Horizontal Reference Plane (HRP):	The plane constructed between right and left latero-orbitale (lor-lol)
Vertical Reference Plane (VRP)	: The perpendicular plane constructed from crista galli to HRP
Linear measurements:	
Upper Nasal Width (UNasW)	: The width of the upper nasal cavity from the most inner points on the nasal apertura taken parallel to the HRP (unr-unl).
Lower Nasal Width (LNasW)	: The width of the lower nasal cavity from the most lateral points on the nasal apertura taken parallel to the HRP (lnr-lnl).
Interzygomatic Width (ZygW)	: The width of the zygomatic arch from their most lateral aspect (zr-zl).
BiMaxillary Width (BMaxW)	: The width of the maxilla from bilateral points on the jugal process at the intersection of the outline of the tuberosity of the maxilla and the zygomatic buttress (mxr-mxl).
Upper Interapex Width (UIApW)	: The distance between the apex of the first maxillary incisors (ap1r-ap1l).
Upper Intermolar Width (UIMolW)	:The width between the most lateral points on the buccal surface of the permanent maxillary first molar crown (u6cr-u6cl).
Lower Intermolar Width (LIMolW)	:The width between the most lateral points on the buccal surface of the permanent mandibular first molar crown (l6cr-l6cl).
Angular measurements:	
Lower Nasal Angle (LNasA)	: Angle between cg-lnr and cg-lnl planes
Basal Maxillary Angle (BMaxA)	: Angle between cg-mxr and cg-mxl planes
Upper Intermolar Angle (UIMolA)	: Angle between u6cr-u6br and u6cl-u6bl planes

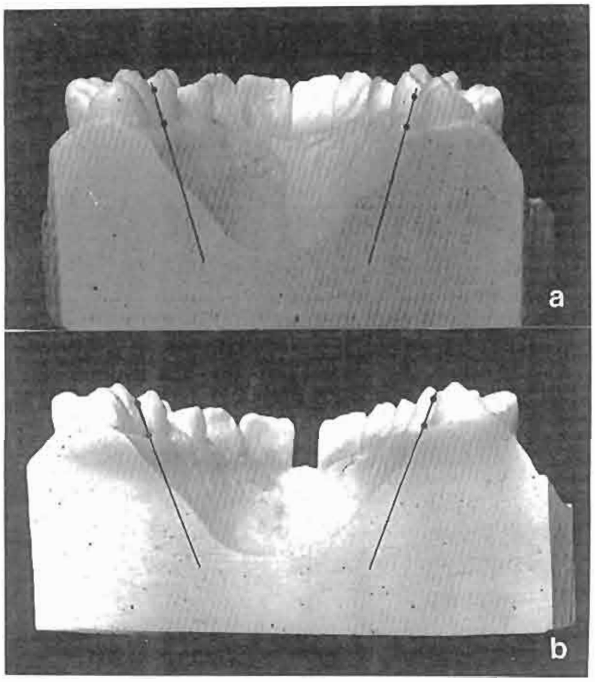

Fig. 4 a and b: Upper first molar reference points and planes. The reference points marked and digitized on the dental cast prints: a. Before expansion, b. After expansion.

tests were used to assess the intra-and intergroup treatment changes respectively (24). Minitab for Windows Statistical Package was used for this purpose.

Reliability of measurements

The reliability of the cephalometric measurements was examined on lateral and PA films of 15 randomly selected subjects, by repeating the point marking and digitising procedures. The reliability of a single measurement was computed by using the formula described by Winner (32). The reliability of measurements ranged between 0.95 to 0.99 in lateral cephalometric variables, and 0.93 to 0.99 in PA measurements (Table IV).

Table IV: Reliability of measurements.

Lateral cephalometric measurements	
s-n-ss	.9941
NSL/NL	.9898
n-sp	.9917
s-pm	.9869
sp-pm	.9571
s-n-sm	.9928
NSL/ML	.9955
Go angle	.9997
NL/ML	.9979
ss-n-sm	.9990
Overbite	.9888
Overjet	.9763
ILs/NL	.9877
ILi/ML	.9969
ILs/ILi	.9867
is-NLv	.9734
ms-NLv	.9888
is-NL	.9903
ii-ML	.9970
ms-NL	.9765
mi-ML	.9888
PA measurements	
UNasW	.9889
LNasW	.9888
IZygW	.9983
BMaxW	.9776
UIApW	.9637
UIMolW	.9982
LIMolW	.9878
NasA	.9614
MaxA	.9301
UIMolA	.9680

RESULTS

Except at upper nasal width, pre-treatment values revealed no significant skeletal and dentoalveolar differences (Tables V and IIX).

During treatment; lower nasal width, interzygomatic width, basal maxillary width and angle, upper first incisor interapex width, upper intermolar widths and lower intermolar widths were significantly increased and LNasW/UIMolW and BMaxW/UIMolW ratios were significantly decreased in the bonded group. Lower nasal width and angle, basal maxillary width and angle, upper intermolar and upper first incisor interapex widths were significantly increased and the ratios were significantly decreased in the banded group (Table V). The upper intermolar angle was markedly increased in the banded group compared to the bonded group, and the difference between the groups was statistically significant (Table VI). Individual molar inclination scores of the patients ranged from -0.80 to 25.05 for the bonded and 8.50 to 56.00 for the banded group (Table VII).

In the sagittal and vertical dimensions, significant skeletal and dentoalveolar responses were observed in both groups. Overbite was markedly reduced in the banded group when compared to the bonded group, and the difference between the two study groups was statistically significant (p<0.01). The upper posterior dentoalveolar height (ms-NL) was markedly increased in both groups. The lower anterior dentoalveolar height (ii-ML) was significantly increased in the bonded group (p<0.01) (Table IIX).

DISCUSSION

When the clinician evaluates RME results, the problem has always been a question of what factors to consider for preventing open-bite and relapse tendency.

Many investigators (5, 15, 18, 31, 33) agree that RME with midpalatal splitting can be accomplished in both adolescents and adults. However, with advancing maturity, the rigidity of the skeletal components limit the extent and the long term stability of the skeletal response (4, 28, 31). Wertz (31) indicated that the optimal age for expansion is between 13 and 15 years of age. Correspondingly, in this study all patients were in the growth period, with a chronological age of 12-14 years at the start of the treatment (Tables I and II).

Molar tipping and extrusion have been shown to be the cause of the bite opening after conventional RME treat-

Table V: Comparison of the pretreatment measurements and treatment changes in transversal dimension between study groups.

	BONDED RME	BANDED RME		BONDED RME	BANDED RME	
	Beginning of treatment	Beginning of treatment		Difference	Difference	
	$\bar{X}$±SD	$\bar{X}$±SD	test	$\bar{D}$±SD	$\bar{D}$±SD	test
Linear measurements (mm)						
UNasW	5.43±2.31	3.22±0.73	**	0.22±0.75	0.02±0.29	
LNasW	29.40±2.41	29.79±3.45		1.64±1.13 ***	1.50±0.69 ***	
IZygW	131.40±4.91	128.85±6.64		0.88±1.49 *	0.39±0.68	
BMaxW	61.57±4.28	63.64±2.32		3.84±2.56 ***	3.29±1.95 ***	
UIApW	7.61±1.44	6.79±1.26		2.17±1.57 ***	3.54±0.82 ***	**
UIMolW	54.03±2.89	53.43±4.00		5.28±1.99 ***	7.01±2.61 ***	
LIMolW	58.30±3.10	58.32±3.55		0.56±0.81 **	0.15±0.66	
Angular measurements (°)						
LNasA	31.89±3.61	31.11±5.12		0.82±2.02	1.32±1.55 *	
BMaxA	53.05±3.26	55.47±2.95		3.07±3.68 ***	3.60±2.47 **	
Ratios						
LNasW/UIMolW	0.55±0.05	0.56±0.08		-0.02±0.02 ***	-0.04±0.03 **	+
BMaxW/UIMolW	1.14±0.06	1.20±0.07		-0.04±0.05 **	-0.09±0.06 **	+

+ p=0.055 * p<0.05 ** p<0.01 *** p<0.001

Table VI: Comparison of the changes in the inclination of the maxillary first molars.

	BONDED RME	BANDED RME	
	$\bar{D}$±SD	$\bar{D}$±SD	Test
UIMolA	9.60±7.43 ***	22.51±13.80 **	*

* p<0.05 ** p<0.01 *** p<0.001

Table VII: Individual molar inclination changes with bonded and banded RME.

	BONDED RME	BANDED RME
case 1	2.50	21.44
case 2	17.21	25.44
case 3	14.59	18.25
case 4	25.05	25.00
case 5	8.18	18.50
case 6	1.70	8.50
case 7	-0.30	10.50
case 8	12.65	19.00
case 9	5.00	56.00
case 10	6.84	
case 11	12.33	
case 12	17.98	
case 13	4.14	
case 14	12.11	
case 15	23.10	
case 16	6.96	
case 17	9.18	
case 18	-0.80	
case 19	15.29	
case 20	0.36	
case 21	7.63	

ment with semi-rigid banded devices (6, 10, 31). Several authors have pointed out that, increasing rigidity of an appliance reduces the rotational component of the forces along the long axis of the teeth (27, 28). Mew (21) reported that, during the intial expansion, the teeth tilted to some extent but tended to upright spontaneously during the period of retention. At the end of retention, the widening was less than the amount which was gained initally, because of the resiliency of the banded RME appliance. In a case report, Sarnas et al. (26) presented a case treated by conventional RME. The patient was followed for ten years with metallic implants and roentgen stereometry. They found largely dental arch expansion than the maxillary bones but followed by marked relapse in dental region. Extensive relapse of rotations as well as translations was found, and the long term effect of RME was shown to be limited. Therefore, to avoid the tipping of the upper molars and to lessen the tendency to re-

Table VIII: Comparison of the pretreatment measurements and treatment changes in sagittal and transversal dimension.

	BONDED RME	BANDED RME		BONDED RME	BANDED RME	
	Beginning of treatment	Beginning of treatment		Difference	Difference	
	x̄±SD	x̄±SD	test	D̄±SD	D̄±SD	test
Maxilla						
s-n-ss (°)	76.53±3.10	78.29±4.73		0.17±1.17	0.07±0.97	
NSL/NL (°)	9.64±3.81	9.59±3.62		0.26±1.48	0.55±1.05	
n-sp (mm)	54.25±3.48	53.47±2.94		0.92±1.27 **	0.73±0.69 *	
s-pm (mm)	46.78±2.80	47.32±4.24		0.66 ±1.27 *	0.29±0.99	
sp-pm (mm)	50.54±3.11	49.34±3.27		0.68±1.66	0.16±0.86	
Mandible						
s-n-sm (°)	75.53±3.00	77.98±5.04		-0.39±0.95	-1.41±1.29 *	
NSL/ML (°)	41.41±5.04	41.27±8.05		0.83±1.33 **	1.74±1.39 **	
Go angle (°)	129.75±7.75	133.65±7.57		0.45±3.17	-0.67±1.16	
Intermaxillary relations						
NL/ML (°)	31.78±5.97	31.68±7.08		0.57±1.37	1.20±1.35 *	
ss-n-sm (°)	1.00±4.27	0.31±2.15		0.56±1.01 *	1.48±0.76 ***	
Dentoalveolar structures						
Overbite	0.51±2.42	-0.05±1.66		-0.61±1.12 *	-2.51±1.20 ***	**
Overjet	1.13±4.72	1.92±4.19		0.59±2.11	1.70±1.54 *	
ILs/NL (°)	108.72±4.69	113.19±8.12		0.67±3.52	-0.45±2.30	
ILi/ML (°)	83.41±7.61	80.68±6.73		0.03±3.23	-0.69±2.07	
ILs/ILi (°)	136.19±8.51	134.45±9.42		-1.39±3.72	-0.05±3.09	
is-NLv (mm)	3.82±1.98	2.68±2.56		0.04±1.21	0.17±0.96	
ms-NLv (mm)	31.11±3.32	30.45±3.23		-0.29±1.51	0.55±1.17	
is-NL (mm)	29.75±2.23	30.04±3.40		0.42±1.08	0.26±0.43	
ii-ML (mm)	40.04±2.92	40.14±2.84		0.46±0.72 **	-0.01±0.55	
ms-NL (mm)	23.99±2.51	25.26±2.12		0.82±1.36 *	1.45±0.79 ***	
mi-ML (mm)	31.77±2.42	32.35±3.00		0.11±1.20	0.03±1.10	

* p<0.05 ** p<0.01 *** p<0.001

lapse, a more rigid type of RME device, namely, a full occlusal coverage acrylic bonded appliance was used in the present study.

Lower nasal, basal maxillary and maxillary incisor inter-apex and maxillary intermolar widths were increased with both treatment methods, and, no statistically significant differences were found between bonded and banded RME groups. However, as shown in Table VI, the inclination of the upper molars in the transversal direction was much more increased in the banded group compared to the bonded group. Despite the high variability, the difference between the two study groups was statistically significant. Hicks (13) also reported that the amount of tipping in the molars could range from 1 to 24 degrees during expansion. In the present study change in the inclination of the molars resulted in a marked increase of the posterior upper dentoalveolar height (p<0.001), and posterior rotation of the mandible in the banded group. Thus, overbite was markedly reduced in the banded group (-2.51 mm), while only slightly decreased in the bonded group (-0.61 mm), and the difference between the two groups was statistically significant (p<0.01).

The significantly less amount of increase in the inclination of the upper molars in the bonded group would be explained by the full coverage of all teeth with acrylic and the bonding procedure, that resulted with an increase in rigidity and probably thereby preventing the increase of molar tipping and extrusion to a certain extent. The above finding might be also confirmed by the changes in the ratios between the lower nasal width and upper intermolar width and bimaxillary width and upper intermolar width (p=0.055, Table V). Again, the more skeletal effect than dental effect achieved in the bonded group may have resulted due to this increased rigidity. This procedure seems to have resulted in an effective control of the vertical dimension and bite opening, even though most of the subjects in the bonded group had a steep mandibular plane, an obtuse gonial angle and an insufficient overbite. Moreover, as occlusal contacts were eliminated by the bonded RME appliance, some amount of change of overbite may also be attributed to the eruption of the lower incisors in the bonded group (Table VIII).

The findings of Sarnas et al. (26) revealed that 83% of molar tipping relapsed in a RME case which was followed up for ten years. On the other hand, the results of the present study suggest that the rigid acrylic bonded RME appliance causes less molar tipping, and therefore this outcome may lead to less relapse expectancy in the long term. Furthermore, the evaluation of individual cases treated with the same rigid acrylic bonded RME device have showed no showed no evidence of relapse two years after the removal of the appliance (20, 29).

Dento-skeletal changes in the three dimensions

The changes obtained by the bonded RME device were as follows: linear and angular transversal increases were observed in the nasal cavity, basal maxilla and maxillary dentoalveolar structures by using the rigid acrylic bonded RME device. On the other hand, our findings also indicated that the greatest widening was observed in the dentoalveolar area, and the widening effect of the bonding device gradually decreased through the upper structures. Similar findings were also observed in the banded RME group. Previous studies have shown that, in the frontal plane, the separation of the two maxillary halves follows a triangular pattern (9, 10, 17, 18, 30, 31), with its base downward and the centre of rotation located near the frontonasal suture (30). Our findings support these observations and other previous studies (8-10, 23, 31), which indicate that the width of the nasal cavity particularly the floor of the nose, increases significantly following the RME.

In his metallic implant studies, Krebs (16, 18) found that the amount of sutural opening was equal to or less than one-half of the amount of dental arch expansion. This is also supported by the present study. But in the bonded group, the mean increase in the basal maxillary width was more than one-half of the amount of intermolar expansion (Table IV).

Lingual uprighting or tipping and extrusion of the maxillary incisors relative to the S-N plane in 76% of the cases was reported by Haas (9) and Wertz (30). Similar amounts of maxillary incisor extrusion were found in our study. However, no lingual tipping of the upper incisors was found, probably due to the design of the bonding RME appliance, which was in contact with the maxillary incisors during both expansion and retention periods.

No significant differences between the study groups were observed in the maxillary basal structures. The mandible was displaced backwards and ss-n-sm and overjet was increased in both of the treatment groups, without any significant differences between the groups. However, more prominent changes were observed in the banded group.

Clinical findings and suggestions

The laboratory and clinical work necessary to fabricate and to fix the bonded RME appliance is easy, quick and less expensive than the banded RME devices. Both appliances were tolerated well by the patients. Most of the patients in both groups developed speech problems during the first days following the appliance insertion, but all disturbances disappeared during the second week of active treatment. Gingival inflammation was observed in all patients from both groups. However, gingival and palatal tissues returned to their normal appearance within a week. Therefore, in order to keep the oral hygiene in optimum condition, we recommend to remove the bonded RME appliance at the end of active treatment and use it as a removable plate until the end of retention period.

CONCLUSIONS

The findings of this study suggest that satisfactory treatment results can be obtained with both methods. However, our findings also indicate that the skeletal response is more with the bonded RME. Therefore, this appliance may be an acceptable alternative to the conventional banded RME appliances, especially in cases with mandibular deficiency and insufficient overbite.

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ADDRESS FOR CORRESPONDENCE:
T. Ufuk Toygar MEMİKOĞLU
Ankara Üniversitesi
Diş Hekimliği Fakültesi,
Ortodonti Anabilim Dalı,
06500 Beşevler, Ankara.
Turkey