ORIGINAL ARTICLE

Improving Class II malocclusion as a side-effect of rapid maxillary expansion: A prospective clinical study

Susan S. Guest,[a] James A. McNamara, Jr.,[b] Tiziano Baccetti,[c] and Lorenzo Franchi[c]
Ann Arbor and Canton, Mich, and Florence, Italy

Introduction: The objective of this prospective clinical study was to evaluate the dentoalveolar and skeletal effects induced by rapid maxillary expansion (RME) therapy in mixed dentition patients with Class II Division 1 malocclusion compared with a matched untreated Class II Division 1 control group. **Methods:** The treatment sample consisted of cephalometric records of 50 patients with Class II malocclusion (19 boys, 31 girls) treated with an RME protocol including an acrylic splint expander. Some patients also had a removable mandibular Schwarz appliance or maxillary incisor bracketing as part of their treatment protocol. Postexpansion, the patients were stabilized with a removable maintenance plate or a transpalatal arch. The mean age at the start of treatment of the RME group was 8.8 years (T1), with a prephase 2 treatment cephalogram (T2) taken 4.0 years later. The control sample, derived from the records of 3 longitudinal growth studies, consisted of the cephalometric records of 50 Class II subjects (28 boys, 22 girls). The mean age of initial observation for the control group was 8.9 years, and the mean interval of observation was 4.1 years. All subjects in both groups were prepubertal at T1 and showed comparable prevalence rates for prepubertal or postpubertal stages at T2. Independent-sample Student *t* tests were used to examine between-group differences. **Results:** Class II patients treated with the described bonded RME protocol showed statistically significant increases in mandibular length and advancement of pogonion relative to nasion perpendicular. The acrylic splint RME had significant effects on the anteroposterior relationship of the maxilla and the mandible, as shown by the improvements toward Class I in the maxillomandibular differential value, the Wits appraisal value, and the ANB angle. Patients treated with the bonded RME showed the greatest effects of therapy at the occlusal level, specifically highly significant improvement of Class II molar relationship and decrease in overjet. Treatment with the acrylic splint RME had no sustainable effects on the skeletal vertical dimension, maxillary skeletal position, or maxillary dentoalveolar dimensions. **Conclusions:** This study suggests that the protocol described including treatment with a bonded rapid maxillary expander used in the early mixed dentition in Class II Division 1 patients can help to improve the Class II malocclusion as a side-effect, both skeletally and dentally. Evidence for this phenomenon was based previously on anecdotal data; the results of this study show that the improvements are far more pervasive than anticipated. (Am J Orthod Dentofacial Orthop 2010;138:582-91)

Class II malocclusions are observed commonly in orthodontic patients, comprising up to one-third of the orthodontic population in the United States.[1] Such patients can have several dentoskeletal combinations, with an abnormal skeletal pattern or a normal skeletal pattern with an altered dental arrangement.

Another component of Class II malocclusions that is important to consider during treatment planning, but often is overlooked, is the transverse dimension. Tollaro et al[2] showed an underlying transverse discrepancy of 3 to 5 mm in many dental arches with Class II malocclusions without posterior crossbites in centric occlusion. When these Class II patients were asked to posture their lower jaw forward in a Class I relationship, this discrepancy (ie, maxillary constriction) could be observed clinically. Vargervik[3]

[a]Graduate Orthodontic Program, University of Michigan, Ann Arbor; private practice, Canton, Mich.
[b]Thomas M. and Doris Graber Endowed Professor of dentistry, Department of Orthodontics and Pediatric Dentistry, School of Dentistry; professor of cell and developmental biology, School of Medicine; research professor, Center for Human Growth and Development, University of Michigan, Ann Arbor; private practice, Ann Arbor, Mich.
[c]Assistant professor, Department of Orthodontics, University of Florence, Florence, Italy; Thomas M. Graber Visiting Scholar, Department of Orthodontics and Pediatric Dentistry, School of Dentistry, University of Michigan, Ann Arbor.
The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.
Reprint requests to: James A. McNamara, Department of Orthodontics and Pediatric Dentistry, University of Michigan, Ann Arbor, MI 48109-1078; e-mail, mcnamara@umich.edu.
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similarly reported on the commonality of maxillary constriction of Class II malocclusion patients. She stated that the correction of a Class II molar relationship without the creation of a posterior crossbite requires an increase in maxillary molar width relative to the mandibular molar width of approximately 2 mm for unilateral Class II and 4 mm for bilateral Class II molar relationship.

The transverse discrepancy discussed is not self-correcting during the mixed dentition transition.[4] This discrepancy, often caused by constriction of the maxilla in Class II patients, has been shown to be both dental and skeletal.[5] Rapid maxillary expansion (RME) therapy therefore is indicated in these patients during the mixed dentition.

RME has been in common use by orthodontists for several decades. Although expansion initially was used to correct posterior crossbites and gain arch perimeter, more possible indications for this technique have been proposed.[1,6] McNamara[1,7] advocated the use of expansion in many early mixed dentition Class II patients with mild mandibular retrusion and maxillary constriction. A removable mandibular Schwarz appliance can be used initially to upright the mandibular posterior teeth orthodontically, followed by an orthopedic bonded maxillary expander. The occlusion is stabilized by using a maintenance plate in the mixed dentition or a transpalatal arch or full appliances in the permanent dentition. Widening the maxilla to an overexpanded position (maxillary molar lingual cusps approximating the mandibular molar buccal cusps) often leads to spontaneous forward posturing of the mandible during the retention period.[7-9] In these patients, the expanded maxillary arch appears to have the function of an endogenous functional appliance that solicits the mandible to be postured into a more anterior position.[1]

Lima Filho and Oliveira Ruellas[9] investigated slow and rapid maxillary expansion in Class II skeletal patients, with 1 group treated with Kloehn cervical headgear while gradually expanding the inner bow. The second group consisted of patients treated with cervical headgear and RME. They reported significant changes in profile analysis with respect to mandibular protrusion in Class II skeletal patients treated with RME. There were significant increases of SNB, B-Hor, and Pog-Hor between the treatment intervals for both treated groups.[9]

The aim of this study was to describe the anteroposterior effects induced by RME therapy in Class II Division 1 patients, focusing specifically on changes that contribute positively to the correction or improvement of a Class II molar relationship.

MATERIAL AND METHODS

This investigation was a prospective clinical trial that was part of a larger study of RME conducted in a private practice setting. This longitudinal study was designed to evaluate cephalometrically the skeletal and dentoalveolar effects achieved by treatment with RME in Class II patients compared with a matched control group of Class II subjects.

The primary study sample consisted of 1135 consecutive patients who were treated with RME in the mixed dentition. Treatment was performed in 1 practice by orthodontists who followed a standardized protocol and were homogeneous as to clinical skill and expertise.

Cases were not considered if full records were not taken at the time of the second observation just before full braces (phase 2 treatment). Other reasons for initial exclusion from enrollment, or for dropouts from the prospective study, were extracted or congenitally missing teeth, use of a banded expander or additional mechanics (such as a functional appliance or utility arches during the observation period), thus leaving a subsample of 574 subjects.

Additional exclusionary criteria were applied, reducing the sample to include only Class II Division 1 patients who met the dentitional criteria of all deciduous molars and permanent first molars and incisors at the start of treatment (T1) and all premolars fully erupted about 4 years later before full-appliance treatment (T2). Moreover, all subjects enrolled in the final treatment sample had maxillary constriction shown by an initial mean transpalatal width measurement of 30 mm or less. This measurement was determined during the initial examination and was measured clinically from the most lingual aspect of 1 maxillary first permanent molar to its antimere.[1]

To summarize, the rigorous enrollment criteria were Class II tendency malocclusion (end-to-end first permanent molars) or Class II molar relationship (full-cusp) at T1, early mixed dentition with all 8 first and second deciduous molars at T1 and received a bonded maxillary expander, cephalograms available at 2 observation times (T1 and T2), and early permanent dentition at T2 with all 8 premolars erupted fully.

The final sample consisted of 50 patients with Class II Division 1 malocclusion. The mean age at T1 of the treated group was 8.8 years, with the T2 cephalograms taken 4.0 years later on average (Table I).

From a pool of untreated subjects followed longitudinally throughout growth, a control group of 50 subjects with Class II malocclusion was matched with the treatment subjects. The cephalograms of the untreated subjects were obtained from 3 longitudinal growth

Table I. Demographics at observation times

Group	T1 age (y)		T2 age (y)		T2-T1 (y)	
	Mean	SD	Mean	SD	Mean	SD
RME (19 boys, 31 girls)	8.8	1.1	12.8	1.1	4.0	0.9
Control (28 boys, 22 girls)	8.9	0.9	12.9	1.0	4.1	0.5

studies to obtain the best match possible to the treatment group, based on the same inclusion criteria described above. Twenty-three subjects were from the University of Michigan Elementary and Secondary Growth Study (Ann Arbor), 21 subjects were from the Broadbent-Bolton Collection at the Bolton-Brush Growth Study Center (Cleveland, Ohio), and 6 subjects were used from the Denver Growth Study (Colo). The mean age at the start of observation for the control group was 8.9 years, and the mean time of observation at T2 was 4.1 years (Table I).

Significant effort was directed toward matching the control sample to the treatment sample as closely as possible with respect to sex (male:female ratio), dentition (all deciduous molars present at T1 and all permanent premolars fully erupted at T2) to account for the loss of leeway space in both groups, skeletal maturity (as measured by the cervical vertebral maturation (CVM) stage[10] at T1 and T2), chronologic age at T1 and T2, equal numbers of Class II and Class II tendency (end-on) malocclusions, and observation interval.

At T1, all subjects, both treated and untreated, were prepubertal according to the method derived by Baccetti et al[10] in 2005. At T2, there were no significant differences between prevalence rates for prepubertal and postpubertal stages in the treated group compared with the untreated group (Table II).

All patients received a bonded acrylic splint RME after the T1 cephalogram for an average of 6.7 months. The expansion screw was activated until the palatal cusps of the maxillary posterior teeth approximated the lingual cusps of the mandibular posterior teeth.[1] Twenty-nine, or 58%, of the patients wore a removable mandibular Schwarz expansion appliance before the maxillary expansion appliance. Thirty-five patients also had brackets placed temporarily on the maxillary incisors. Forty-eight treated patients received an acrylic palatal plate for retention after removal of the RME; 2 patients were given a transpalatal arch for retention of expansion after RME removal because of the loss of the maxillary second deciduous molars at RME removal. All patients received a transpalatal arch before the cephalogram at T2. Eleven patients

Table II. Distribution according to cervical vertebral maturation (CVM) stage at T2

CVM stage	RME group (19 boys, 31 girls) Subjects at T2 (n)	Control group (28 boys, 22 girls) Subjects at T2 (n)
1	5	3
2	14	10
3	13	11
4	7	17
5	9	9
6	2	0

received a mandibular lingual arch before the T2 cephalogram.

Both lateral cephalograms of each patient were hand-traced on 0.003-in matte acetate with a 2H lead pencil at a single sitting. Cephalograms were traced by 1 investigator (S.S.G.); landmark location and the accuracy of the anatomic outlines were verified by a second (J.A.Mc.). The functional occlusal plane was included on each tracing. A customized digitization regimen (version 2.5, Dentofacial Planner, Toronto, Ontario, Canada) that included 78 landmarks and 4 fiducial markers was created and used for the cephalometric evaluation. All measurements were corrected for magnification differences between series and standardized to an enlargement of 8%. The Dentofacial Planner program allowed analysis of cephalometric data and superimpositions among serial cephalograms.

Regional superimpositions on the cranial base, maxilla, and mandible were accomplished by hand, as advocated previously by Ricketts[11] and McNamara.[12] Cranial base superimpositions detected changes in maxillary and mandibular skeletal position. Films were oriented along the basion-nasion line and registered at the most posterosuperior aspect of the pterygomaxillary fissure, with the contour of the cranium posterior to the foramen magnum used to verify the accuracy of the superimposition. Maxillary regional superimpositions identified movements of the maxillary dentition relative to the maxillary basal bone. The maxilla was superimposed along the palatal plane by registering on bony internal details of the maxilla superior to the incisors, and the superior and inferior surfaces of the hard palate. Mandibular regional superimpositions characterized movements of the mandibular dentition relative to the mandibular basal bone. Mandibular superimpositions were performed posteriorly on the outline of the inferior alveolar nerve canal and any tooth germs (before root formation) and anteriorly on the internal structures of the mandibular symphysis.

Table III. Comparison of starting forms

Cephalometric measurement	RME group n =50 Mean	RME group n =50 SD	Control group n = 50 Mean	Control group n = 50 SD	RME vs control Mean difference	RME vs control P value†	
Cranial base							
Ba-S-N (°)	130.7	4.2	130.3	4.7	0.4	0.633	NS
Maxillary A-P skeletal							
SNA (°)	81.3	3.5	80.4	3.0	0.9	0.165	NS
Mandibular A-P skeletal							
SNB (°)	76.2	3.5	74.9	2.6	1.3	0.041	*
Co-Gn (mm)	98.1	4.2	96.4	4.6	1.7	0.067	NS
Intermaxillary							
ANB (°)	5.1	1.8	5.4	2.1	−0.3	0.415	NS
Wits (mm)	1.4	1.7	2.1	2.3	−0.7	0.092	NS
Vertical skeletal							
FMA (°)	25.3	4.4	26.2	4.7	−0.9	0.360	NS
Interdental							
Overjet (mm)	5.9	1.8	6.1	1.7	−0.2	0.530	NS
Overbite (mm)	3.4	2.2	3.8	2.9	−0.4	0.459	NS
6/6 (mm)	−0.8	0.8	−1.0	1.0	0.2	0.153	NS

*$P < 0.05$; *NS*, not significant; †Independent-sample Student *t* test.

Statistical analysis

Descriptive statistics, including means and standard deviations, were calculated for age, duration of treatment, values at T1 and T2, and changes between T1 and T2 of all cephalometric measures for the 2 groups. The data were analyzed with a Windows-based statistical software package (version 12.0, SPSS, Chicago, Ill). Statistical significance was tested at $P < 0.05$, $P < 0.01$, and $P < 0.001$.

After the assessment of normal distribution of the data (Shapiro Wilks test), independent-sample Student *t* tests were used to examine between-group differences of the means of the cephalometric measures of the starting forms of the 2 groups, as assessed on the basis of a series of diagnostic variables. Comparison of T2 to T1 changes over time between the treated and untreated groups also was accomplished with independent-sample Student *t* tests.

The power of the study also was calculated by the SPSS software. The statistical power of a study indicates the probability that a significant difference between groups can be detected when one truly exists. The power of a statistical test is influenced by the variance of the means, the common standard deviation of sample means, the level of significance at which the test is run, and the sample size. On the basis of the expected differences in the changes of molar relationship (main target variable) between the 2 groups, given the sample size (n = 50) and a *P* value of 0.05, the power of this study was 100%. This means that there is no probability that one does not see the differences described by chance alone (false negatives).

As mentioned previously, assembling a well-matched control group of untreated Class II subjects was the highest priority in designing this study. Exploratory chi-square statistical tests were performed for sex distribution and skeletal maturity levels measured by the CVM stage at T2 (all subjects in both groups were prepubertal at T1). There was no significant difference for sex distribution of the 2 samples (chi-square = 2.57; $P = 0.109$). There also was no significant difference among the 2 groups at T2 for the prepubertal or postpubertal CVM stages (chi-square test = 2.60; $P = 0.107$); this emphasizes the adequacy of the matched control group.

Thirty-two patients in the treated group were categorized as Class II tendency at T1, and 18 had full-cusp Class II malocclusions initially. Similarly, 30 subjects in the control group had a Class II tendency molar relationship at T1, and 20 had full-cusp Class II malocclusions. Differences between the cephalometric T1-T2 changes for the Class II tendency subgroup of patients and the Class II subgroup of patients in both groups were tested statistically (Mann-Whitney U tests, $P < 0.05$). Differences in outcomes among subgroups of subjects treated with different protocols (Schwarz appliance, maxillary bracketing, maintenance plate, and lingual arch) were tested with Mann-Whitney U tests ($P < 0.05$). The use of nonparametric statistics for these comparisons was due to the limited number of subjects in each group.

Table IV. Comparison of changes during observation

Cephalometric measurement	*RME group n = 50* Mean	SD	*Control group n = 50* Mean	SD	*RME vs Control* Mean difference	P value[§]	
Cranial base							
Ba-S-N (°)	0.9	2.1	0.2	1.8	0.7	0.113	NS
Maxillary A-P skeletal							
SNA (°)	0.3	1.6	0.7	1.8	−0.4	0.213	NS
Pt A-Na perp (mm)	0.1	1.4	0.1	1.3	0.0	0.936	NS
Co-Pt A (mm)	5.1	2.0	5.4	2.1	−0.3	0.591	NS
Mandibular A-P skeletal							
SNB (°)	1.2	1.4	1.1	1.6	0.1	0.627	NS
Pg-Na perp (mm)	1.9	1.9	0.8	2.1	1.1	0.005	†
Co-Gn (mm)	9.1	2.9	7.8	3.0	1.3	0.024	*
Co-Go (mm)	4.9	3.8	3.7	2.6	1.2	0.085	NS
Intermaxillary							
ANB (°)	−0.9	1.3	−0.4	1.4	−0.5	0.036	*
Wits (mm)	−0.5	1.5	0.7	1.7	−1.2	0.001	†
Mx/mn diff (mm)	4.0	2.2	2.4	2.3	1.6	0.001	†
Vertical skeletal							
FH-FOP (°)	−1.7	2.4	−1.7	3.3	0.0	0.925	NS
FH-PP (°)	−0.8	2.0	−0.8	2.1	0.0	0.981	NS
FMA (°)	−0.8	1.7	−0.9	1.7	0.1	0.773	NS
Gonial angle (°)	−1.7	2.4	−1.8	2.7	0.1	0.825	NS
UFH (mm)	4.8	2.0	4.4	1.5	0.4	0.259	NS
LAFH (mm)	3.7	2.2	3.5	1.9	0.2	0.696	NS
Interdental							
Overjet (mm)	−0.8	1.6	0.2	1.2	−1.0	0.001	†
Overbite (mm)	1.2	2.0	1.2	1.8	0.0	0.975	NS
I/I (°)	1.4	8.4	2.6	6.9	−1.2	0.414	NS
6/6 (mm)	1.8	1.0	0.1	0.8	1.7	0.000	‡
Maxillary dentoalveolar							
U1-FH (°)	−0.4	5.3	−1.7	4.7	1.3	0.200	NS
U1-Pt A vert (mm)	0.7	1.2	0.6	1.4	0.1	0.515	NS
U1H (mm)	0.9	1.3	0.6	1.3	0.3	0.260	NS
U1V (mm)	2.0	1.5	2.2	1.1	−0.2	0.337	NS
U6H (mm)	1.2	1.4	1.4	1.5	−0.2	0.446	NS
U6V (mm)	1.0	1.3	1.4	1.6	−0.4	0.119	NS
Mandibular dentoalveolar							
IMPA (°)	−0.9	5.1	−1.0	4.6	0.1	0.897	NS
L1-APg (mm)	0.4	0.9	−0.1	1.1	0.5	0.011	*
L1H (mm)	0.2	1.3	0.5	1.1	−0.3	0.145	NS
L1V (mm)	3.3	1.4	2.7	1.6	0.6	0.053	NS
L6H (mm)	2.0	1.4	2.0	1.3	0.0	0.842	NS
L6V (mm)	2.8	1.5	2.1	1.9	0.7	0.050	NS
Soft tissue							
UL to E-plane (mm)	−2.3	1.7	−1.4	3.1	−0.9	0.062	NS
LL to E-plane (mm)	−1.4	1.9	−1.1	3.0	−0.3	0.460	NS
Nasolabial angle (°)	−0.4	10.1	4.1	13.1	−4.5	0.060	NS

NS, not significant.
**P* <0.05; †*P* <0.01; ‡*P* <0.001; §Independent-sample Student *t* test.

RESULTS

Descriptive data and statistical comparison for starting forms and cephalometric changes in the 2 groups from T1 to T2 are given in Tables III and IV, respectively.

Significant between-group differences at T1 were noted for only 1 measurement. The RME group had a larger SNB angle (76.2°) relative to the controls (74.9°), representing a slightly more orthognathic facial profile than was seen in the control group. The significance level was 0.041, barely significant at the *P* <0.05 level. For all other measurements, the 2 groups were similar cephalometrically at T1.

From T1 to T2, the RME group had a significant advancement of pogonion (1.1 mm), as measured

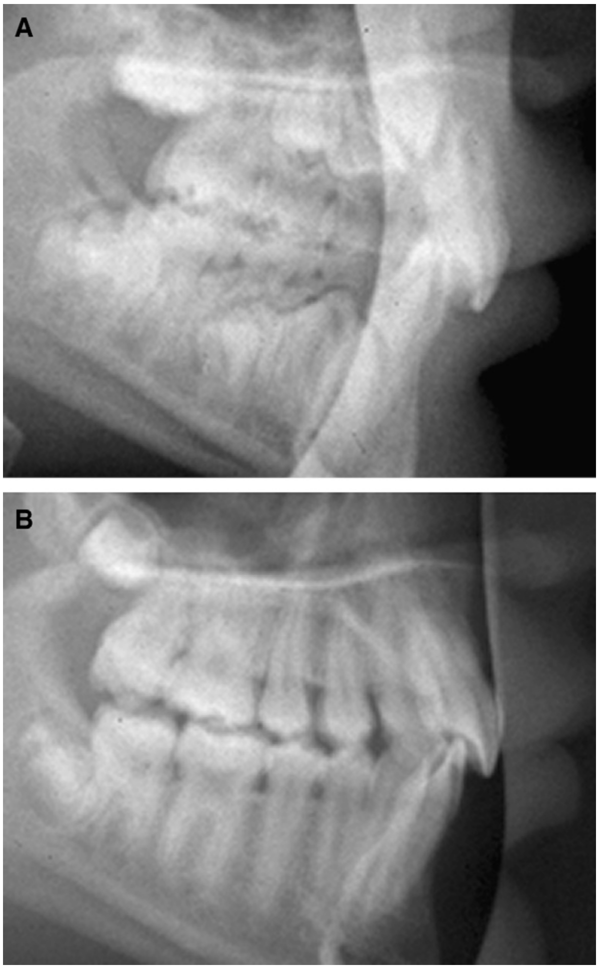

Fig 1. Cephalometric example of a treated end-on Class II malocclusion subject at T1 and T2: **A**, pretreatment at 9 years 10 months; **B**, postexpansion and maintenance plate stabilization, before phase 2 treatment at 13 years 4 months.

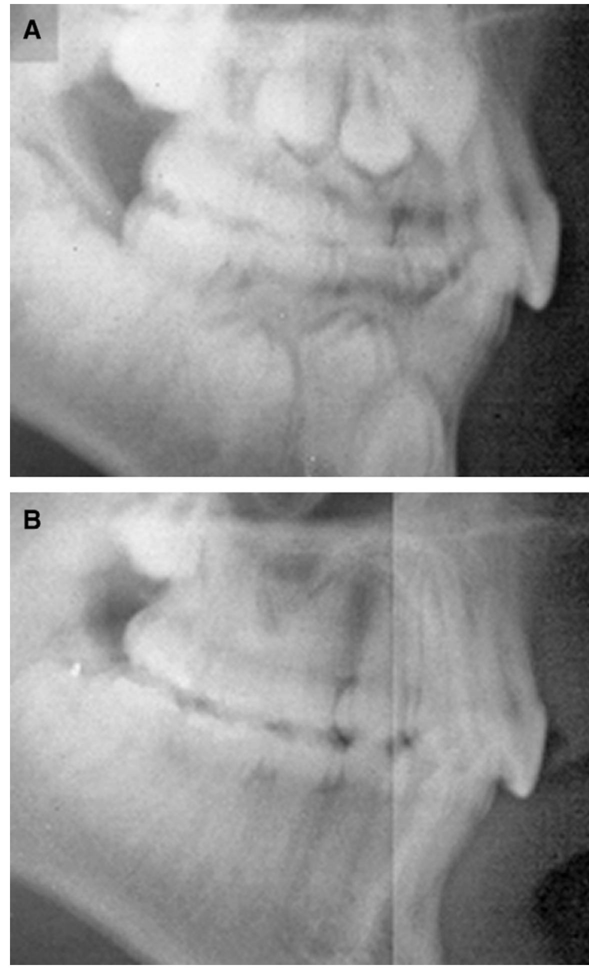

Fig 2. Cephalometric example of an untreated end-on Class II malocclusion subject at T1 and T2: **A**, 10 years of age; **B**, 4 years later.

from nasion perpendicular, when compared with the control group ($P = 0.005$). The change in mandibular length, as measured from condylion to gnathion, also was significant between the groups, with a mean increase of 1.3 mm for the treated group relative to the control values.

The values for ANB angle ($P = 0.036$) and the Wits appraisal ($P = 0.001$) were decreased significantly in the RME treated group compared with the control group. Also, there was a highly significant difference in the maxillomandibular differential between the 2 groups. The control group measured a mean difference of 1.6 mm less for the difference in midfacial and mandibular lengths compared with the treated group ($P = 0.001$).

There were no significant differences of vertical skeletal measurements between the 2 groups.

The most significant change overall came in the molar relationship measured from the mesial aspect of the maxillary first molar to the mesial aspect of the mandibular first molar along the occlusal plane ($P = 0.0001$). The mean difference of this measurement was 1.7 mm greater for the treated group compared with the controls. Overjet was decreased significantly in the treated group by 1.0 mm compared with the control group at a significance level of $P = 0.001$. Lower 1 to A-pogonion measured 0.5 mm greater in the treated vs control groups.

No differences were found between the cephalometric T1-T2 changes for Class II tendency patients and Class II patients in both groups. There were no

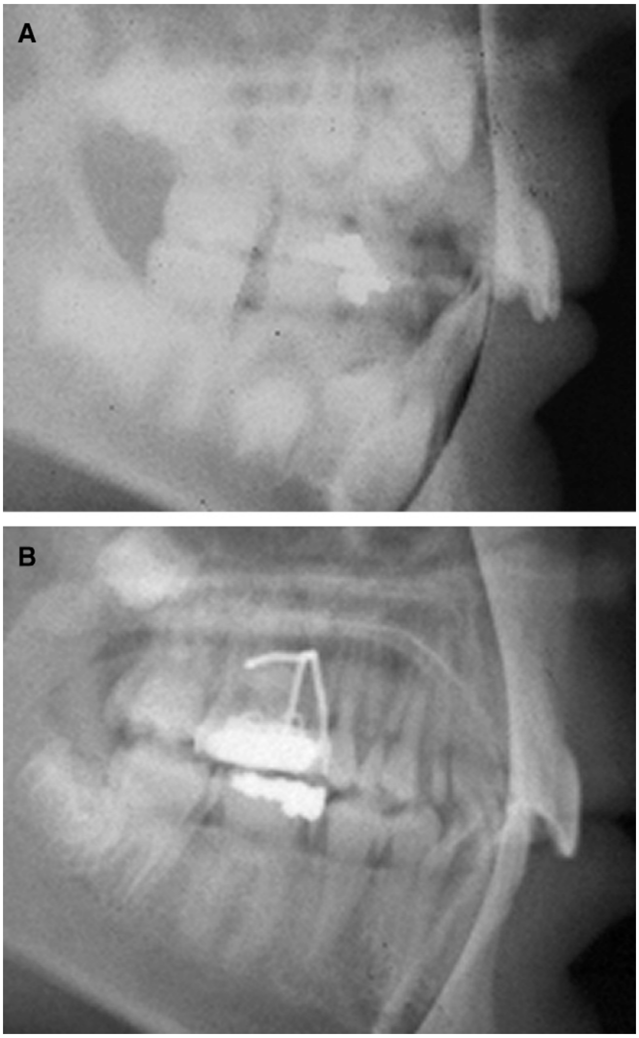

Fig 3. Cephalometric example of a treated Class II malocclusion subject at T1 and T2: **A**, pretreatment at 8 years 9 months; **B**, postexpansion and transpalatal arch stabilization, before phase 2 treatment at 12 years 4 months.

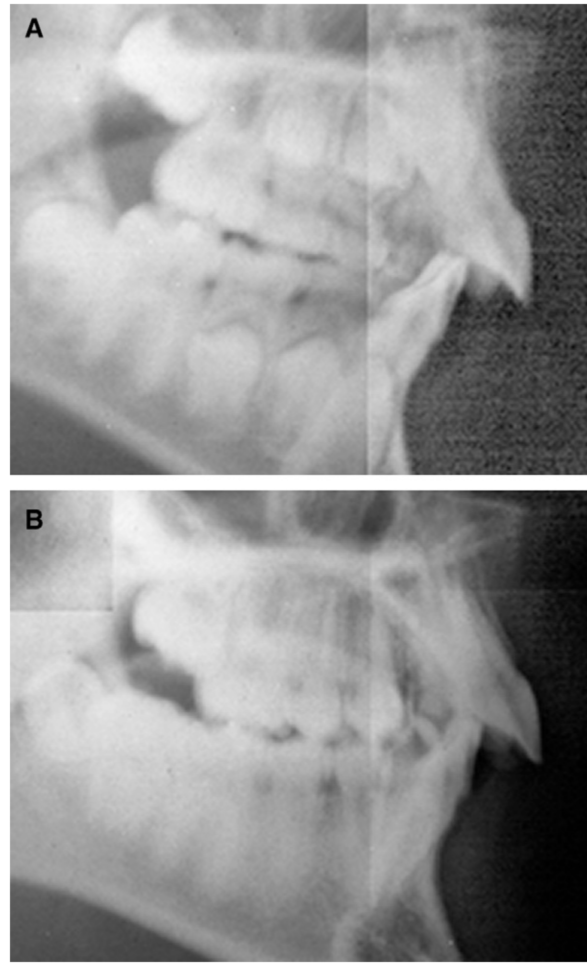

Fig 4. Cephalometric example of an untreated Class II malocclusion subject at T1 and T2: **A**, at 8 years 7 months of age; **B**, 4 years later.

significant differences among the cephalometric results from the patients in the treated group with respect to the presence of a Schwarz plate, bracketing of the maxillary incisors, palatal plate, or a mandibular lingual arch.

DISCUSSION

This study, part of a long-term prospective clinical investigation of RME, was aimed at describing the skeletal and dentoalveolar effects of the bonded acrylic splint RME in Class II malocclusion used in early mixed dentition patients compared with a matched control group. The significant treatment effects seen in this study will be discussed in further detail.

For the mandibular anteroposterior skeletal effects, this study showed a significant increase in the measurement of pogonion to nasion perpendicular of 1.9 mm in the treated group, compared with 0.8 mm in the Class II control group. This mean advancement of 1.1 mm in pogonion over the control group was significant ($P = 0.005$). The results also demonstrated a significant increase in mandibular length, as measured from condylion to gnathion, in the treated group (9.1 mm) compared with control values (7.8 mm).

Significant intermaxillary skeletal effects of the RME appliance also emerged when the overall sagittal relationship of the maxilla to the mandible was compared. The mean ANB angle and Wits appraisal values decreased significantly in the RME group when

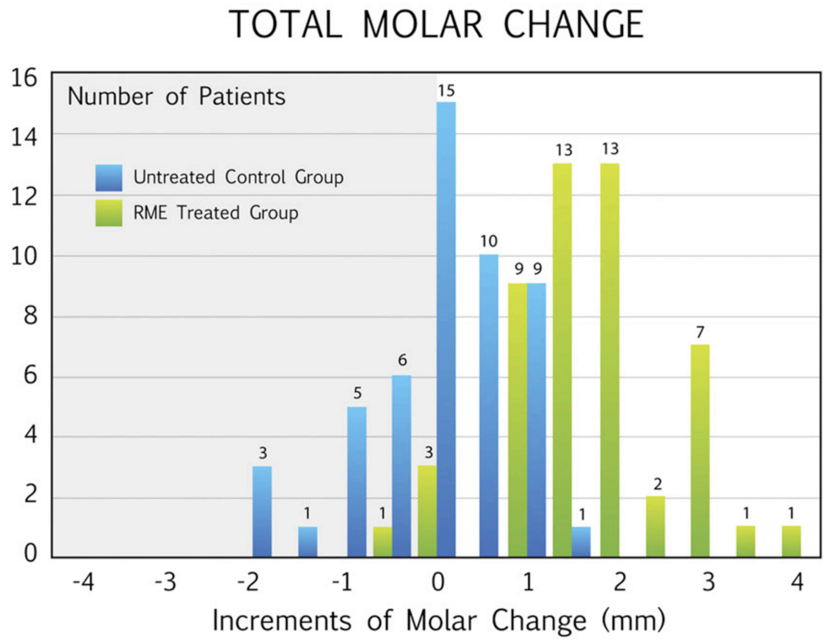

Fig 5. Graphical representation of changes in molar relationship in treated and control groups.

compared with the untreated Class II group. The ANB angle decreased by 0.5°, and the Wits value decreased by 1.2 mm in the treated group compared with the controls. Both of these differences were statistically significant (Table IV). The maxillomandibular differential also was highly significant ($P = 0.001$), in that the mean difference between the groups was 1.6 mm. All of these differences indicate significant improvements of the initial Class II malocclusions in the treated group.

The only mandibular dentoalveolar measurement that was significant in this category of effects was the lower 1-A-pogonion measurement, which showed a mean increase of 0.5 mm for the treated group (0.4 mm) in comparison with the controls (–0.1 mm).

The greatest statistically significant interdental effect of the RME compared with the untreated group was in the molar relationship difference. The mean molar relationship improvement from a Class II toward a Class I malocclusion was 1.8 mm in the treated group compared with 0.1 mm in the controls. This difference of 1.7 mm was highly significant ($P < 0.001$) and clinically relevant (Figs 1-4). Overjet also decreased by 1.0 mm in the treated group compared with the untreated group, a difference that was statistically significant.

No other significant anteroposterior maxillary skeletal, vertical, or maxillary dentoalveolar effects were seen in the cephalometric measures for the treated group compared with the control group.

The clinical significance of this study illustrates that both skeletal and dentoalveolar treatment effects of RME occur routinely; these effects are important in the serendipitous sagittal improvement of a Class II malocclusion after therapy. As shown in Figure 5, 46 of the 50 treated patients showed positive molar changes equal to or greater than 1 mm, compared with only 10 in the control group. On the other hand, 40 control subjects had neutral or unfavorable molar changes ($< +1$ mm) between the mixed and permanent dentitions, compared with only 4 in the treated group. In other words, 92% of the treated group spontaneously improved their Class II molar relationship by 1 mm or more, and almost 50% of the treated patients had improvements in molar relationship of 2 mm or greater, without definitive Class II mechanics incorporated into the protocol (Figs 1 and 3). There also were significant skeletal improvements from RME treatment, including increased mandibular length, pogonion advancement, and reductions in the ANB angle and the Wits appraisal value 3.5 years after active expansion therapy was completed.

Observations in the control group in this study confirm previously published data on longitudinal observations of untreated subjects with Class II malocclusions.[4,13,14] Arya et al,[13] for example, observed that all patients with a distal-step relationship of the second deciduous molars ultimately demonstrated a Class II relationship of the permanent molars. In our study, only

20% of the control subjects improved their molar relationship by 1 or 1.5 mm, which indicates that, once a subject has a Class II malocclusion, without treatment he or she likely will remain with a Class II malocclusion in subsequent years (Figs 2 and 4).

The favorable effects of RME therapy on anteroposterior relationships occurred in both full-cusp Class II and half-cusp Class II subjects. This protocol originally was recommended from clinical anecdotal observations only in half-cusp Class II subjects;[1] the results of our study indicate that spontaneous improvement of Class II malocclusion occurs equally in both half-cusp and full-cusp Class II relationships.

These results also indicate the importance of evaluating the transverse features of Class II patients in the mixed dentition to determine the need for RME therapy. Methods advocated by Tollaro et al[2] and McNamara and Brudon[1] allow for a quick and easy evaluation of transverse discrepancy during the clinical examination, at least at the occlusal level, by having the Class II Division 1 patient posture his or her lower jaw forward into a Class I position to identify a discrepancy.

The phenomenon of improvement of a Class II malocclusion in RME patients originally was based on anecdotal data, but this study shows that the improvements observed are far more pervasive than anticipated. It is almost as if this protocol acts as a functional appliance during the observation period because it is well retained, making the subsequent Class II or even Class I malocclusion patient easier to treat in the second phase. Specifically in the vast majority of patients, the improvements at the occlusal level can make it possible to treat any remaining anteroposterior discrepancy with Class II elastics only, if desired.

CONCLUSIONS

This study showed the following.

1. The bonded RME had its greatest effects at the occlusal level, specifically producing highly significant improvements of Class II molar relationship and decreases in overjet. The Class II molar relationship remained virtually unchanged in the control group, whereas the RME group showed improved molar relationships of over 1 mm in 92% of the expansion patients and over 2 mm in almost 50% of them.
2. The bonded RME had significant effects on the anteroposterior relationship of the maxilla and mandible, as shown by the significant improvements of the maxillomandibular differential, the Wits appraisal, and the ANB angle, once again with improvements between 1 and 2 mm or degrees.
3. Class II patients treated with the bonded acrylic splint RME protocol showed statistically significant increases in mandibular length and advancement of pogonion related to nasion perpendicular, although the increases were of modest magnitude.
4. Treatment with the bonded RME had no sustainable effects on the skeletal vertical dimension, the maxillary skeletal position, or the maxillary dentoalveolar dimension. Treatment with RME showed significant overall positive (toward Class I) changes for Class II malocclusion subjects. Regardless of the magnitude of the mean values of the changes, these improvements were not the consequence of any specific mechanics aimed at Class II correction, and they led to a significant reduction of the distal molar relationship.

REFERENCES

1. McNamara JA Jr, Brudon WL. Orthodontics and dentofacial orthopedics. Ann Arbor, Mich: Needham Press; 2001.
2. Tollaro I, Baccetti T, Franchi L, Tanasescu CD. Role of posterior transverse interarch discrepancy in Class II, Division 1 malocclusion during the mixed dentition phase. Am J Orthod Dentofacial Orthop 1996;110:417-22.
3. Vargervik K. Morphologic evidence of muscle influence on dental arch width. Am J Orthod 1979;76:21-8.
4. Baccetti T, Franchi L, McNamara JA Jr, Tollaro I. Early dentofacial features of Class II malocclusion: a longitudinal study from the deciduous through the mixed dentition. Am J Orthod Dentofacial Orthop 1997;111:502-9.
5. Franchi L, Baccetti T. Transverse maxillary deficiency in Class II and Class III malocclusions: a cephalometric and morphometric study on postero-anterior films. Orthod Craniofacial Res 2005;8:21-8.
6. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. Am J Orthod 1970;57:219-55.
7. McNamara JA Jr. Early intervention in the transverse dimension: is it worth the effort? Am J Orthod Dentofacial Orthop 2002;121:572-4.
8. Haas AJ. Entrevista: Dr. Andrew J. Haas. R Dental Press Ortodon Ortop Facial 2000;6:1-10.
9. Lima Filho RM, de Oliveira Ruellas AC. Mandibular behavior with slow and rapid maxillary expansion in skeletal Class II patients. Angle Orthod 2007;77:625-31.
10. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod 2005;11:119-29.
11. Ricketts RM. Perspectives in the clinical application of cephalometrics. The first fifty years. Angle Orthod 1981;51:115-50.

12. McNamara JA Jr. A method of cephalometric evaluation. Am J Orthod 1984;86:449-69.
13. Arya BS, Savara BS, Thomas DR. Prediction of first molar occlusion. Am J Orthod 1973;63:610-21.
14. Bishara SE, Hoppens BJ, Jakobsen JR, Kohout FJ. Changes in the molar relationship between the deciduous and permanent dentitions: a longitudinal study. Am J Orthod Dentofacial Orthop 1988;93:19-28.