A longitudinal study of skeletal side effects induced by rapid maxillary expansion

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Orthopedic expansion of the maxillary arch—rapid maxillary expansion (RME)—is a commonly used treatment technique that has become increasingly popular during the last 25 years. During this time, however, clinicians routinely have imputed a variety of undesirable side effects to RME, particularly bite opening. Whereas there have been many explanations as to the mechanisms underlying such RME-related effects as bite opening, few studies have considered the long-term effects of RME in the vertical and sagittal dimensions of the face. The purpose of this investigation was to examine cephalometrically the long-term effect that the Haas-type rapid maxillary expansion may have on bite opening and on the anteroposterior position of the maxilla. The sample consisted of 25 patients who had undergone RME with the Haas-type expander, followed by standard edgewise therapy. This RME sample was compared with a group of 25 patients who had standard edgewise treatment (SET) only and with a control (CTRL) group of 23 subjects. Mean initial form and mean age at start of treatment for the RME, SET, and CTRL groups were similar. Statistically significant among-group differences were documented for only 2 of 10 cephalometric variables sensitive to anteroposterior and vertical skeletal changes. These differences, however, were not clinically significant. The current investigation implies therefore that RME therapy with the Haas-type expander has little long-term (more than 6 years after treatment) effect on either the vertical dimensions or the anteroposterior dimensions of the face. (Am J Orthod Dentofac Orthop 1997;112: 330-7.)

Orthopedic expansion of the maxillary arch—rapid maxillary expansion (RME)—has been accomplished for more than a century. Since the inception of this procedure, however, clinicians routinely have attributed undesirable side effects to RME. "I didn't want to expand the patient (using RME) because I was afraid of opening his bite" is a statement often heard from the practicing orthodontist. Given the assumption that RME opens the bite, many clinicians consider an anterior open bite or a steep mandibular plane angle (or both) to be an outright contraindication to RME use. Hultgren et al.[1] have shown the unfavorable treatment effects associated with excessive bite opening during treatment.

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In support of this assumption, the literature is replete with studies that seem to affirm the notion that RME opens the bite and also moves the maxilla downward and forward. It should be noted, however, that most of these investigations considered only the *short-term changes* associated with RME therapy.[2-10] Long-term studies of the side effects associated with RME treatment are few, and those studies that have examined patients 5 or more years after treatment[11-13] typically lacked both treated and untreated controls and adequate statistical power, and their samples spanned wide age ranges.

THE EFFECT OF RME ON CRANIOFACIAL STRUCTURES

Several theories have been advanced to explain how RME therapy might cause bite opening, at least over the short-term. The most obvious explanation, which usually is observed immediately after expansion is completed, concerns the disruption of the posterior occlusion. The maxillary arch typically is overexpanded relative to the mandibular arch, and the resultant posterior cuspal relationships cause transient bite opening. In addition, the maxillary first molars may be extruded during the process of rapid maxillary expansion,[14,15] and this movement also can open the bite. Further, Melsen and Melsen[16] have argued that RME is sufficiently traumatic to produce fractures in the region of the maxillary tuberosity, thus facilitating maxillary displacement. In this way, RME can result in downward and forward displacement of the maxilla in patients who have had RME therapy.

Haas[6] has advanced a theory as to why "the maxilla always moves downward and forward with rapid maxillary expansion." Specifically, because of the sutural orientation of the maxilla, growth produces a downward and forward vector of maxillary movement. The *hafting zone* (circummaxillary) sutures are disengaged by palatal expansion, and "as the maxillae are forced apart and these sutures begin to open, the force produces an effect similar to growth, so that the maxilla moves downward and forward." Denticulated sutures open, the bones slide, and the denticles bind like ratchets to prevent the return of the maxilla to its former position.

Another possible mechanism of maxillary movement is reminiscent of the septopremaxillary ligament hypothesis[17] in relation to maxillary growth. Ohshima[18] asserted that "new bony spicules . . . deposited in a direction perpendicular to the inferior border of the vomer revealed evidence of a downward displacement of the maxilla." Ohshima implied that osteogenic activity at the vomeromaxillary suture pushes the maxilla downward or at least facilitates the downward displacement of the maxilla.

In a 1973 study, Biederman[19] suggested how the anterior maxilla at point A can come forward with RME therapy: If the center of rotation of the expansion is located at the posterior of the maxilla at the junction between the hamular and pterygoid plates, then the paired maxillae rotate about these points and point A comes forward. Biederman[19] also proposed a mechanism for bite opening: if the maxilla disarticulates from the nasal bones and walls of the ethmoid, then the bite closes. If these bones do not disarticulate but instead bend, then subsequent remodeling tips the palatal plane down at the posterior nasal spine, which causes an increase in the mandibular plane angle and thereby opening the bite.

Rapid maxillary expansion also exerts considerable force against multiple extramaxillary structures. An examination of the relationship of a maxillary bone to other facial bones reveals that it abuts 10 other osseous structures. It is plausible then that RME could produce skeletal effects remote from the maxilla. Given that Isaacson and Ingram[20] have demonstrated that an RME appliance can exert up to 30 pounds of force against the maxilla, enough force might be exerted against other facial sites that circummaxillary sutural growth may be promoted. By encouraging such growth, RME could cause bite opening.

An additional mechanism has been proposed that involves structures distant from the circummaxillary sutural system. In Gardner and Kronman's[21] study with rhesus monkeys, RME produced 0.5 to 1.0 mm of opening in the sphenoccipital synchondrosis. From this observation, Gardner and Kronman suggested that the opening at the sphenoccipital synchondrosis might be another method by which the maxilla moves downward and forward.

Thus there are many explanations as to how the side effects of RME may be produced, but few studies have considered the long-term significance of these treatment effects. The current retrospective, longitudinal study examines the nature of the side effects produced as a result of RME treatment in combination with conventional edgewise mechanics, as well as the persistence of such effects during the posttreatment period. This study also explores the popular conjecture that patients with high mandibular plane angles have an increased risk of bite opening.

PATIENTS AND METHODS

Sample Selection

This study compared a group of patients who received RME as part of their overall treatment protocol with a matched group of patients whose orthodontic treatment did not include RME. The edgewise-treated control group was generated by the same private practitioner (T.A.H.) as the RME-treated group, thereby minimizing the potential effects of interclinician differences. The third group was an untreated control group selected from the records of the University of Michigan Elementary and Secondary School Growth Study[22] that was age matched to the RME-treated group.

RME group: The RME sample for this study was derived from the long-term records of patients who had undergone RME and nonextraction edgewise appliance therapy in a single orthodontic practice. The practitioner attempted to contacted all RME patients who were treated from 1972 through 1985, regardless of the treatment outcome. The parent sample of 86 patients represent those patients from whom the private practitioner obtained long-term records. The records obtained on this patients included initial and deband lateral cephalograms and study casts and posteroanterior cephalograms at immediate postRME screw fixation and at deband. Lateral cephalograms and study models also were obtained 5 or more years after treatment. The fact that the same records were taken on all patients should minimize detection bias.[23]

These patients originally were judged by the practitio-

Table I. Mean maxillary intermolar width (mm)

	T_1	T_2	T_3	$\Delta(T_3 - T_1)$
RME	30.6	35.4	35.2	4.6
SET	33.7	34.9	35.4	1.7
CTRL	34.7	35.6	35.9	1.1

Table II. Average age of the three groups

	RME	SET	CTRL
Time 1	11y 8m	11y 8m	11y 8m
Time 2	14y 8m	14y 8m	14y 5m
Time 3	21y 0m	20y 6m	17y 8m

ner to have transverse maxillary deficiency as part of their overall orthodontic problem. These patients underwent Haas-type rapid maxillary expansion[5] with two turns a day (approximately 0.25 mm per turn) until the expansion screw reached 10.5 mm. The Haas expander was kept on the teeth as a passive retainer for an average of 60 days (range = 32 to 75 days). Fixed standard edgewise appliances were placed immediately after the Haas expander was removed.

Of the original 86 patients on whom long-term records were available, one patient had the RME removed prematurely and two patients had inadequate radiographs that revealed posterior teeth not in occlusion. An additional 32 patients started treatment outside the 10.25- through 13.25-year-old age range considered in this study. Of the remaining 51 patients, 33 were female and 18 were male. Each patient was assigned a random number, and 18 female and 7 male patients were selected with the aid of a random number generator. Ultimately, the RME group included 25 patients (7 male and 18 female) who underwent treatment with a Haas-type rapid maxillary expander who were selected from the parent group of 86 nonextraction patients.

Standard Edgewise Treatment (SET) Group: Twenty-five patients (7 male and 18 female) who underwent nonextraction standard edgewise therapy (SET) were selected from a larger group of patients so treated by the same practitioner providing the RME group. The SET group patients were matched by age and sex to the RME group patients but otherwise were selected randomly. Patients who received extraction therapy were excluded from consideration. The SET group served as a positive control, in that the SET and RME groups were treated similarly, except for the use of the RME appliance in the RME group, inclusion of the SET group controlled for bite opening that can occur from leveling with fixed orthodontic appliances alone. The major difference between the RME group and the SET group was in transpalatal width. The average transpalatal width at the level of the lingual groove of the first molars was 30.6 mm for the RME group and 33.7 mm for the SET group (Table I).

Control Group (CTRL): Twenty-three subjects (16 male and 7 female) who did not undergo orthodontic treatment were selected from the records of the University of Michigan Elementary and Secondary School Growth Study.[21] The control group subjects were matched by age to the RME group patients. The average transpalatal width of the CRTL group (34.7 mm; Table I) was slightly greater than that of the SET group.

Cephalometric Analysis

Lateral cephalograms were analyzed for each patient at pretreatment (T_1), end-of-active-treatment (T_2), and posttreatment (T_3) times (Table II). The cephalometric analysis used was a modified and expanded version of the McNamara analysis.[24-26] Serial lateral cephalograms were hand-traced and then superimposed on the basion-nasion line, with registration on the pterygomaxillary fissure.[24] Superimposition was checked against the posterior cranial outline as well. All tracings were performed by one investigator (J.Y.C.) and subsequently verified by another investigator (J.A.M.). The lateral cephalograms were digitized with a customized digitization package. From the digitized lateral cephalograms, 30 measurements were derived for each patient at each time.[25,26] The RME and SET groups had varying magnifications that ranged from 6% to 8%, whereas the CTRL group subjects had a 12.92% magnification. All linear cephalometric measures were converted to an 8% enlargement to standardize the data.[25] The error of the method has been published previously.[26]

Cast Analysis

Direct measurements of the maxillary and mandibular casts were taken to the nearest 0.1 mm with vernier calipers. The following dimensions were measured:

1. *Maxillary intermolar width*: The distance from the right to left first molar measured from the gingival margins at the lingual grooves of the first molars.
2. *Overbite*: The distance that the maxillary right central incisor overlapped the mandibular right central incisor, as viewed from an aspect perpendicular to the occlusal plane.
3. *Overjet*: The distance from the lingual surface of the maxillary right central incisor to the facial surface of the mandibular right central incisor at the mesiodistal midpoint of the maxillary central.

Statistical Analysis

Descriptive statistics for each group, including means and standard deviations, for each of the cephalometric and dental cast measures were calculated for time 1 (T_1) measures. Of the 30 cephalometric variables, 10 were statistically analyzed more extensively with repeated-measures analysis of variance (ANOVA) to examine patterns over time. These 10 measures represent the only variables that provided information on vertical or anteroposterior skeletal dimensions or both.

The current null hypotheses that there is no significant long-term bite opening or anteroposterior maxillary change associated with RME therapy were tested with two-way repeated-measures ANOVA, with group (RME, SET, and CTRL) as the "between subjects" factor and time (initial, deband, and posttreatment) as the "within subjects" factor. Repeated measures ANOVA takes into account the fact that a measure taken on a person at one time is correlated with the same measure taken at a previous time, that is, large amounts of growth would not be expected in a person who is constitutionally small. The repeated measures design allows one to test whether changes across time are similar for all three sample groups. This comparison is the interaction effect in the repeated measures ANOVA model.

The cephalometric measures at specific times were analyzed for the three groups (RME, SET, and CTRL) by comparing the differences among groups from time 1 to time 2 ($\Delta[T_2\text{-}T_1]$), time 1 to time 3 ($\Delta[T_3\text{-}T_1]$), and time 2 to time 3 ($\Delta[T_3\text{-}T_2]$) for each of the 10 measures.

These measures were examined by one-way ANOVA for each separate time interval. Post-hoc comparisons between treatment groups were made with independent *t* tests. Statistical significance was tested at $p \leq 0.05$. One must bear in mind that no Bonferroni or Tukey's correction was made; therefore a type I error will occur 5% of the time by chance alone.

RESULTS

Analysis of Starting Form

The RME, SET, and CTRL groups generally had similar characteristics for 30 cephalometric and three cast measures at initial presentation. There were statistically significant differences between the RME and SET groups in starting form for midfacial length (Condylion – point A), Co – ANS, and maxillomandibular differential.[23] Because these three measures are interrelated, significance with one of the variables likely would generate significance in the other two. Also, because 30 ANOVAs were run at a $p \leq 0.05$ level, one would expect 1.5 of the measures to be statistically significant by chance alone. Of the 30 measures, three were statistically significant between RME and CTRL groups: U6 horizontal, U1 horizontal, and midfacial length. Thus it appears that the three groups generally were similar in most cephalometric characteristics at the onset, although it should be noted that the RME group had twice as many subjects with mandibular plane angles greater than 27° (Table III). In addition, the RME group had a narrower transpalatal width in comparison to the other two groups (Table I), but were otherwise similar.

The average ages for each group taken at T_1, T_2, and T_3 were comparable (Table II), except at T_3, in that cephalograms on the untreated sample from the University of Michigan Growth Study were available only until the late teen years. The RME and SET groups had the same proportion of male and female patients in each sample (18 females, 7 males). The CTRL group, however, had almost the reciprocal gender proportion: 16 males and 7 females.

Table III. Mandibular plane angle at the start of treatment (T_1)

	RME	*SET*	*CTRL*
Mean MPA	28.1°	25.0°	25.4°
SD	5.9°	4.9°	4.9°
>27°	17	8	8
≤27°	8	17	15

The distribution of Angle classification for each group at the start was similar. Of the RME sample (N = 25), 12 (48%) subjects had Class I malocclusions, 13 (52%) had Class II malocclusions, and none had Class III malocclusions. For the SET group, the identical breakdown in Angle classification was observed. Crossbites, both unilateral and bilateral, were found in 18 (72%) of the RME patients. In the SET group, only two (8%) of the patients had crossbites. As one might expect, maxillary intermolar width was the only feature that distinguished the RME from the SET group (Table I). The mandibular plane angle for each group also was similar at the beginning of treatment (Table III).

Statistics

The 10 measures (Tables IV to VI) sensitive to anteroposterior or vertical skeletal changes or both were analyzed statistically with the repeated-measures ANOVA. Overall, no among-treatment differences were seen. Within-groups, however, all measures changed over time, apparently as a by-product of normal growth.

There was scant evidence of treatment-time interaction. Of 90 individual contrasts, only two showed statistical significance. Treatment change in the SNA angle (T_1 to T_2) was 1° less in the RME group than in the control group (Table IV), and overall change in the mandibular plane angle (T_1 to T_3) was less in the RME group than in the edgewise group (Table VI). Because individual trends can be masked by statistical analyses such as the repeated measures ANOVA, it perhaps is appropriate to illustrate graphically the individual changes in the

Table IV. Comparison of treatment effects from initial (T_1) to end of treatment (T_2)

Variable	RME (N = 25)		SET (N = 25)		CTRL (N = 23)		Significance		
	Mean	SD	Mean	SD	Mean	SD	RME-SET	RME-CTRL	SET-CTRL
LAFH	3.44	2.09	3.85	1.29	4.02	2.07	NS	NS	NS
Na Perp - Pt A	−0.62	0.89	−0.12	1.31	0.23	1.64	NS	NS	NS
Na Perp - Po	0.65	2.22	1.48	1.62	1.28	2.96	NS	NS	NS
Mandibular plane	0.19	1.62	−0.77	1.31	−0.34	2.26	NS	NS	NS
Facial axis	−0.21	1.62	0.13	1.19	−0.18	1.75	NS	NS	NS
SNA	−0.52	1.00	−0.07	1.59	0.53	1.60	NS	*	NS
SNB	0.46	1.14	0.77	1.22	0.76	1.45	NS	NS	NS
ANB	−0.98	1.43	−0.84	1.01	−0.23	1.44	NS	NS	NS
Facial plane	0.63	1.03	1.02	0.84	0.88	1.52	NS	NS	NS
Palatal plane	−0.77	1.48	−0.76	0.94	−0.86	1.55	NS	NS	NS

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS*, not significant.

Table V. Comparison of treatment effects from end of treatment (T_2) to posttreatment (T_3)

Variable	RME (N = 25)		SET (N = 25)		CTRL (N = 23)		Significance		
	Mean	SD	Mean	SD	Mean	SD	RME-SET	RME-CTRL	SET-CTRL
LAFH	2.45	2.51	1.55	1.79	2.60	2.01	NS	NS	NS
Na Perp - Pt A	0.13	0.94	−0.15	0.72	0.12	0.77	NS	NS	NS
Na Perp - Po	0.87	2.37	1.16	2.08	1.56	1.53	NS	NS	NS
Mandibular plane	−1.04	1.73	−1.75	2.12	−1.87	1.44	NS	NS	NS
Facial axis	0.39	1.20	0.88	1.26	0.55	0.80	NS	NS	NS
SNA	0.23	1.21	−0.40	0.92	−0.09	0.82	NS	NS	NS
SNB	0.50	1.22	0.18	1.10	0.49	0.84	NS	NS	NS
ANB	−0.27	1.40	−0.59	0.96	−0.58	0.73	NS	NS	NS
Facial plane	0.55	1.16	0.65	1.07	0.87	0.71	NS	NS	NS
Palatal plane	−0.41	1.52	−0.21	0.80	−0.04	1.02	NS	NS	NS

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS*, not significant.

Table VI. Treatment effects from initial (T_1) to posttreatment (T_3)

Variable	RME (N = 25)		SET (N = 25)		CTRL (N = 23)		Significance		
	Mean	SD	Mean	SD	Mean	SD	RME-SET	RME-CTRL	SET-CTRL
LAFH	5.89	3.40	5.40	2.28	6.62	2.90	NS	NS	NS
Na Perp - Pt A	−0.49	1.17	−0.27	1.20	0.35	1.51	NS	NS	NS
Na Perp - Po	1.52	2.88	2.65	2.59	2.84	3.90	NS	NS	NS
Mandibular plane	−0.85	2.22	−2.52	2.19	−2.21	2.92	*	NS	NS
Facial axis	0.18	1.56	1.01	1.57	0.38	2.23	NS	NS	NS
SNA	−0.29	1.42	−0.47	1.46	0.44	1.65	NS	NS	NS
SNB	0.95	1.67	0.96	1.56	1.25	1.87	NS	NS	NS
ANB	−1.25	1.55	−1.43	1.05	−0.81	1.63	NS	NS	NS
Facial plane	1.17	1.41	1.67	1.27	1.76	1.86	NS	NS	NS
Palatal plane	−1.19	1.89	−0.94	1.00	−0.90	1.66	NS	NS	NS

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; *NS*, not significant.

mandibular plane angle (MPA) from T_1, T_2, and T_3 for the RME group (Figs. 1 and 2).

Because of the significant difference in MPA, a sign test was used to examine patients with a "high MPA" (arbitrarily defined as MPA > 27°). Of the 17 patients with high MPA in the RME group, the MPA decreased in 13 (76.5%) and increased in 4 (23.5%) from T_1 to T_3. These trends can be compared with the SET group, in which are all the original eight patients with high MPA (again defined as MPA > 27°), MPA decreased from T_1 to T_2. According to Fisher's exact test, there was no significant difference in outcomes between the RME and SET groups.

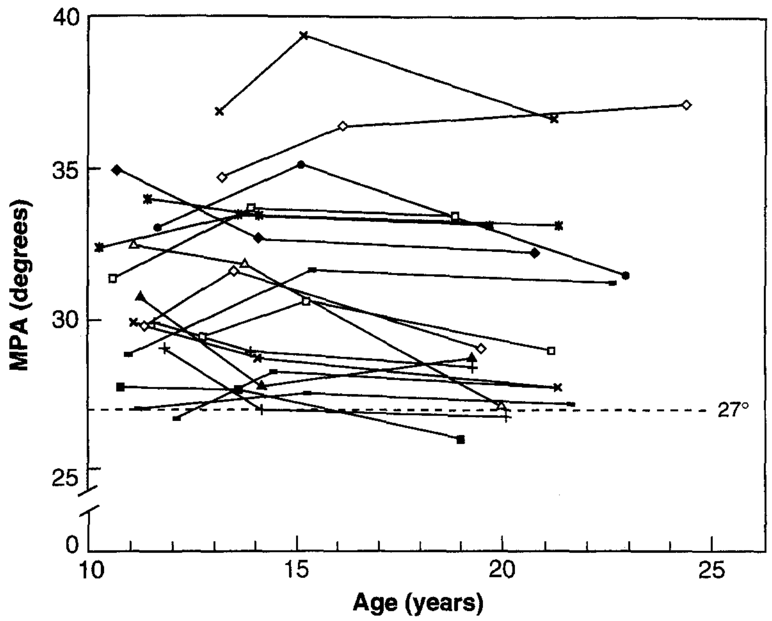

Fig. 1. Individual changes in mandibular plane angle (MPA) during treatment and posttreatment period in patients with initial higher MPA. Three observation points indicated for each patient correspond to T_1 (initial), T_2 (end of treatment), and T_3 (posttreatment).

Furthermore, within the RME group, Fisher's exact test was used to see whether the patients with high MPA responded differently to RME therapy than did patients with low MPA. In the sign test, four (23.5%) of the patients with high MPA (N = 17) increased in MPA from T_1 to T_3, and 13 (76.5%) decreased. Of the patients with low MPA (N = 8), five (62.5%) increased and three (37.5%) decreased. Fisher's exact test showed no significant difference between the low and high MPA groups on change in MPA.

DISCUSSION

The current present study does not support the claim that bite opening (i.e., increase in lower anterior facial height or opening of the mandibular plane angle or both) occurs in patients with Class I and Class II malocclusions treated with RME.

Furthermore, this investigation shows that RME does not significantly alter anteroposterior maxillary position over the long term.

Vertical Dimension. Schudy[27] was one of the first orthodontists to stress the importance of controlling the vertical dimension of the face in patients who have an anteroposterior imbalance between the upper and lower jaws. Schudy emphasized that increasing a patient's vertical dimension can aggravate any preexisting anteroposterior discrepancy.

Transverse, vertical, and anteroposterior skeletal malrelationships often coexist in a single patient. A clinician who wishes to correct a transverse problem in such a patient and who bases treatment decisions on the existing literature might initiate unnecessary treatment (e.g., vertical-pull chincup) or fail to render appropriate treatment for fear of "opening the bite." In fact, the results from the current study suggest that the Haas-type RME will not open the bite over the long term, even for the higher mandibular plane angle patient.

To test the idea that patients with high MPA tend to react more negatively to RME therapy by having greater bite opening than patients with low angles, Fisher's exact test was used. No relationship between a high pretreatment MPA (defined here as MPA > 27°) and a tendency to increase in MPA over time was shown. Furthermore, a sign test revealed that 76.5% of patients with high MPA showed bite closure from T_1 to T_3; whereas, only 37.5% of the patients with low MPA showed bite closure over the same observation period.

This trend seems to contradict the idea that the bite of the patient high MPA tends to open more readily than that of the patient with low MPA. One could argue that bite closure was observed more often in high than patients with low MPA, as a result of preferential treatment, that is, the practitioner

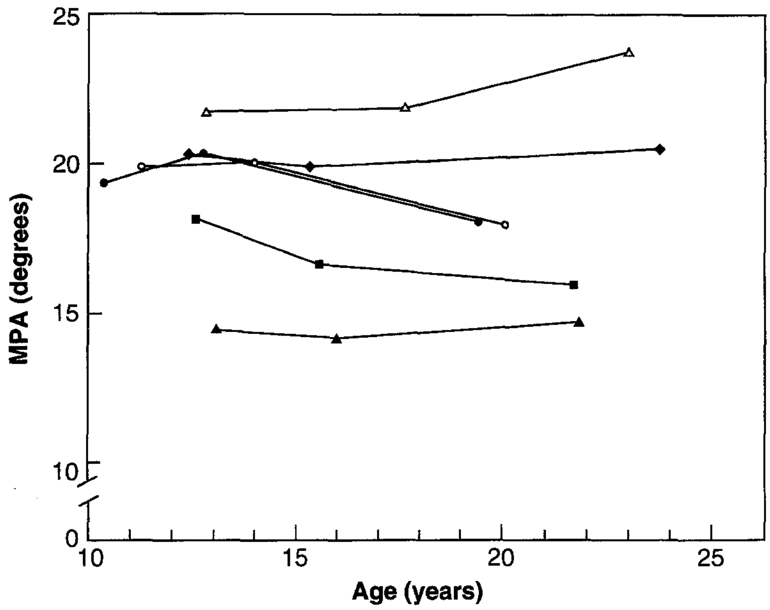

Fig. 2. Individual changes in mandibular plane angle (MPA) during treatment and posttreatment period in patients with initially lower MPA. Three observation points indicated for each patient correspond to T_1 (initial), T_2 (end of treatment), and T_3 (posttreatment).

took more care to control the vertical dimension in the patients with high MPA. Conversely, more patients with high angle probably were found in the RME group because they are more likely to have constricted arches in need of widening. The latter was borne out in the analysis of starting form. Only 8 (32%) of 25 patients had initially high MPAs in the SET group, whereas 17 (68%) of 25 RME patients had a starting MPA greater than 27° (Table III).

Maxillary Position. For the SNA angle, post hoc testing revealed a significant difference between RME and CTRL groups from T_1 (initial) to T_2 (end of treatment). In the RME group, SNA decreased ~0.5° from the beginning to the end of active treatment. In the CTRL group, the SNA angle increased ~0.5° during the same time period. In previous investigations, Haas[3,6,13,28] and Wertz[11] claimed that point A comes forward. None of these studies quantified the amount that point A came forward, and none compared that amount with the normative data. In the current study, change in the SNA angle between the RME and CTRL groups was observed to be statistically different; however, the mean change from T_1 to T_2 for RME and CTRL groups were within 1° of each other, an amount that is clinically insignificant. More importantly, no statistical significance for change in the SNA angle from the beginning of treatment to the posttreatment period was observed among any of the three groups. Furthermore, nasion perpendicular to point A,[23] another measure that might show significance should the maxilla come forward, did not show statistically significant changes. It should be noted, however, that Class III malocclusion was not represented in any of the three groups studied, so no conclusions can be drawn regarding the effect of RME on the movement of point A in patients with Class III malocclusions.

CONCLUSIONS

The purpose of this investigation was to examine the long-term effect of the Haas-type RME on bite opening and on the anteroposterior position of the maxilla. There was no significant difference among groups receiving rapid maxillary expansion, followed by edgewise treatment (RME), standard edgewise therapy alone (SET), or no treatment (CTRL) for 8 of the 10 cephalometric variables (facial axis angle, SNB, ANB, nasion perpendicular to pogonion, nasion perpendicular to point A, facial plane, palatal plane, and lower anterior facial height). A statistically significant difference was seen for the SNA angle between RME and CTRL groups from initial to deband; however, this difference was clinically insignificant (~1°). Furthermore, there was no significant overall among-group difference in the SNA angle.

Finally, there was a statistically significant overall difference for the MPA between RME and SET groups.

Although the MPA decreased over the duration of observation in each group, the average decrease in the SET group exceeded that of the RME group by ~1.6°. This difference, however, may not be clinically significant.

The current investigation of long-term treatment effects concludes therefore that RME therapy used in the treatment of patients with Class I and Class II malocclusions does not have a significant long-term effect on either the vertical or the anteroposterior dimensions of the face.

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