Original Article

Long-term Clinical Outcome of Rapid Maxillary Expansion as the Only Treatment Performed in Class I Malocclusion

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Abstract: The purpose of this study was to investigate the long-term clinical responses of rapid maxillary expansion as the only treatment performed in Class I malocclusion using the Haas-type appliance. The longitudinal sample consisted of 90 sets of study models from 30 consecutive patients (12 males and 18 females) selected on the basis of the following inclusion criteria: all patients (1) had a Class I malocclusion with transverse maxillary/mandibular skeletal discrepancies, (2) were treated nonextraction in the early/mid mixed dentition, (3) presented with mandibular dental arches with mild or no crowding, and (4) had no subsequent comprehensive orthodontic treatment implemented in either the maxilla or the mandible. The mean age was 8.2 years when treatment was initiated. Treatment outcomes were evaluated at pretreatment A_1, short-term follow-up (one year after A_1) A_2, and long-term follow-up (four years after A_2) A_3. The changes in maxillary arch width and arch length were quantified and compared among assessment stages A_1, A_2, and A_3 using the Student's *t*-test. The results demonstrated a highly significant increase in maxillary arch width in both the short- and long-term follow-ups. The arch width increased significantly during treatment and decreased slightly during the long-term follow-up. The long-term clinical response demonstrated the efficacy and stability of this type of treatment in achieving maxillary arch width. The follow-up examination during the early/mid/permanent dentition confirmed the validity of overtreatment. (*Angle Orthod* 2005;75:416–420.)

Key Words: Rapid maxillary expansion; Class I malocclusion; Long-term

INTRODUCTION

The concept of midpalatal suture opening was first reported in 1860 by Angell.[1] He activated a jackscrew supported by the premolars two turns per day in a patient and reported a separation of the central incisors at the midline with a correction of a posterior crossbite. Subsequently, the clinical short-term effects of rapid expansion on patients treated only with an expansion appliance during the late-mixed and permanent dentitions, as well as repercussions to the craniofacial complex, have been extensively studied.[2–4]

Transverse maxillary deficiencies give rise to several clinical manifestations such as maxillary hypoplasia, asymmetrical facial growth, positional and functional mandibular deviations, altered dentofacial esthetics, adverse periodontal responses, unstable dental tipping, and other functional problems.[5] If this abnormality exists because of a real or relative disharmony in the maxillomandibular relationship, it is clear that a transverse maxillomandibular discrepancy is well suited to orthopedic alteration. Some investigators believe that treatment stability is related to the orthopedic treatment of these discrepancies.

Rapid maxillary expansion (RME) has been widely used and studied for more than 40 years,[2,6,7] and investigators[2–4,8] have studied the changes associated with RME during the early permanent dentition. However, there are no longitudinal studies of patients with Class I dentitions and transverse maxillary deficiencies expanded during the mixed dentition without any additional treatment and assessed again after the eruption of the full permanent dentition.

The objective of our investigation was to evaluate the longitudinal maxillary arch width and length changes in serial models where the clinical response to RME was the only treatment performed.

MATERIALS AND METHODS

This research consisted of a retrospective clinical trial. The longitudinal sample consisted of 90 sets of articulated dental arch casts of 30 (12 males and 18 females) consecutively treated Caucasian patients at the Lima Ortodontia

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Clinic, in São José do Rio Preto, State of São Paulo, Brazil, between 1975 and 1991. The patients' records were selected on the basis of the following criteria: (1) all patients were treated nonextraction in the early/mid mixed dentition, (2) all patients presented a Class I malocclusion with transverse maxillary/mandibular skeletal discrepancies, (3) no subsequent comprehensive orthodontic treatment was implemented in either the maxilla or the mandible, and (4) the mandibular dental arches presented mild or no crowding in all cases. Records were completed within the same clinic because the patients were treated following the norms and quality control criteria proposed by the American Board of Orthodontics Dental Cast Guide.[9]

On the initial dental casts, a crossbite status was noted, with 21 patients presenting unilateral crossbites, seven presenting bilateral crossbites, and eight being associated with some anterior crossbite. Only two individuals had no initial crossbite and presented posterior teeth with a buccal inclination and edge to edge occlusion. Only three patients did not present midline deviations associated with various mandibular shifts.

All patients were treated exclusively with a Haas-type tissue-borne RME. No subsequent comprehensive orthodontic treatment with fixed or active removable appliance was implemented in either the maxilla or the mandible.

The expander screw was activated two quarter-turns (0.5 mm) immediately after cementation. Thereafter, the appliance was activated one quarter-turn in the morning and one quarter-turn in the evening. The subjects were seen at weekly intervals for approximately three weeks. When the desired overcorrection for each patient was achieved (screw openings ranging from 8 to 11 mm), the appliance was stabilized. The expander was in situ during the expansion and stabilization period for a mean time of five months (range three to seven months). After removal of the expander, a loose, removable acrylic plate was inserted within 48 hours. Each patient wore the acrylic plate for a variable amount of time, usually for one year or until short-term follow-up impressions was taken. The total duration of the orthopedic treatment for RME varied from four to eight months.

Dental casts were obtained from the 30 patients at pretreatment (A_1), short-term follow-up (A_2), and long-term follow-up (A_3). The mean age at phase A_1 was eight years and two months (range seven years to nine years 10 months), at phase A_2, nine years and four months (range seven years eight months to 10 years 10 months), and at phase A_3, 13 years and two months (range 12 years eight months to 14 years 11 months). In phase A_3, all the permanent teeth were visible in the oral cavity and the second molars were either present or completing eruption. Only the third molars were absent.

All linear measurements were made directly on maxillary dental casts (Figure 1) with an electronic digital caliper (Fred V Fowler Co, Newton, Mass) recording accurate to 0.01 mm and with the WinWedge version 1.2 software (Tal Technologies Inc, Philadelphia, Pa) allowing data to be directly digitized in the computer in the Excel program.

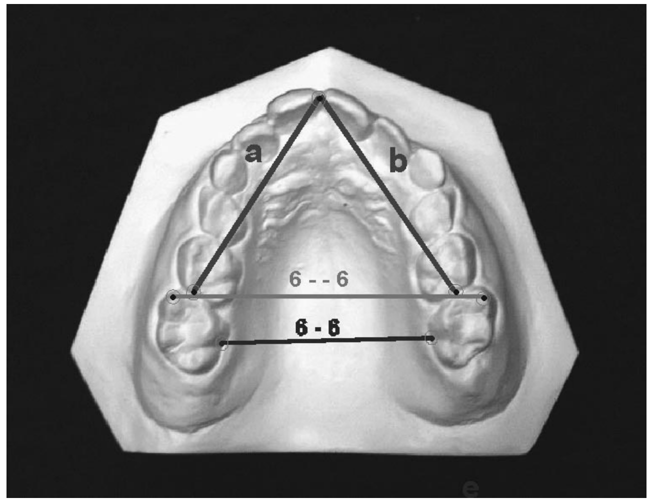

FIGURE 1. Measurements of the maxillary arch width lingual value (6–6), occlusal value (6--6), and arch length (a + b).

Measurements included the following:

1. Arch width at the cervical level according to the recommendations of McDougall et al,[10] ie, measured at the lingual groove with the cervical gingival margin of the first permanent molars (lingual value).
2. Arch width at the occlusal level between the mesiobuccal cusp points of the right and left upper molars (occlusal value).
3. Arch length as the sum of the measurement from the mesial contact point of the first upper right permanent molar to the buccal contact point of the mesial face of the upper right central incisor plus measurement to the mesial contact point of the first upper molar on the left side.

To assess the reproducibility of the study model measurements, preliminary error tests were made. Twenty randomly selected models were remeasured at two time intervals. The greatest difference between the first and second measurements was an absolute value of 0.07 mm, which was considered not significant.

In this research, a comparative method was used with a longitudinal evaluation of the early-mixed dentition phase (A_1), after one year (A_2), and until full permanent dentition (A_3). The analysis of the maxillary arch changes was assessed considering sex, total sample, and long-term evaluation. Analysis of data consisted of standard descriptive statistics. To detect significant alterations between the (A_1) and (A_2), (A_2) and (A_3), and (A_1) and (A_3) evaluation phases, Student's t-test was used ($P < .05$).

RESULTS

A descriptive sex analysis initially was made and the results of the Student's t-test revealed that there were no

TABLE 1. Maxillary Arch Width (Lingual and Occlusal Points ◆) and Arch Length, AL, of the 30 Patients (mm) in the Pretreatment (A_1), Short-term Follow-up (A_2), and Long-term Follow-up (A_3) Phases[a]

Phase	Region	Mean	SD	Min	Max	Q1	Median	Q3
A_1	6--6[b]	32.48	2.25	27.54	36.75	31.44	32.40	33.95
	6--6◆[c]	49.38	2.82	42.83	56.35	47.25	49.57	51.38
	AL	69.89	3.84	62.64	79.20	67.17	69.73	71.16
A_2	6--6	38.06	2.19	32.44	42.30	37.06	38.33	39.38
	6--6◆	55.03	2.41	49.17	61.25	53.64	55.05	56.99
	AL	73.65	2.55	67.92	72.13	72.13	73.60	75.00
A_3	6--6	36.74	2.24	31.32	42.50	35.67	36.84	38.03
	6--6◆	53.92	2.57	49.50	59.17	51.97	53.84	56.01
	AL	72.52	3.56	65.70	85.39	70.23	72.08	74.19

[a] Min indicates minimum; Max, maximum; Q1, first quartile; Q3, third quartile; and AL.
[b] 6--6 indicates permanent intermolar distance.
[c] 6--6◆ indicates mesiobuccal cuspid point (6).

TABLE 2. Paired Differences of the Maxillary Arch Width Between the Lingual Points, Occlusal Points, and AL for the 30 Patients at the Short-term and Long-term Follow-up Phases. The Values Represent the Mean ± Standard Deviation, Minimum and Maximum of the Differences (mm) and Student's *t*-Test[a]

	$A_2 - A_1$		$A_3 - A_1$		$A_3 - A_2$	
Region	Mean	SD	Mean	SD	Mean	SD
6--6[b]	5.58***	1.85	4.26***	1.99	−1.31***	1.51
Min Max	2.45	9.39	0.51	8.06	−3.30	2.88
6--6◆[c]	5.64***	1.80	4.53***	2.14	−1.10**	1.78
Min Max	2.33	9.11	0.50	8.44	−4.40	2.17
AL	3.75***	2.46	2.62***	3.10	−1.13**	2.05
Min Max	−0.69	10.08	−1.78	10.53	−4.67	3.87

[a] Min indicates minimum; Max, maximum, and AL, arch length.
[b] 6–6 indicates permanent intermolar distance.
[c] ◆ indicates mesiobuccal cuspid point (6).
** $P < .01$.
*** $P < .001$.

TABLE 3. Inclination of the Anchor Teeth, Measured Between the Lingual Points Vs Occlusal Points ◆, of the 30 Patients at the Short-term Follow-up (A_2). The Values Represent the Mean ± Standard Deviation, Minimum and Maximum (mm)[a]

Region	Mean	SD	Min	Max
6--6[b]	5.58	1.85	2.45	9.39
6◆--6◆[c]	5.64	1.80	2.33	9.11
Difference	−0.06[NS]			

[a] Min indicates minimum; Max, maximum; and NS, not significant.
[b] 6–6 indicates permanent intermolar distance.
[c] ◆ indicates mesiobuccal (6–6).

statistically significant sex differences when the observed variables in different phases were considered. Therefore, further analyses were performed on the group as a whole.

Descriptive statistics of the width and arch length alterations of the maxillary arches of all the patients, in the studied time intervals, are shown in Table 1. The mean increase in the maxillary arch width, one year after the start of the treatment (A_2) was 5.58 mm for the lingual value and 5.64 mm for the occlusal value, which is highly significant (Table 2).

The mean alterations in the pretreatment evaluation phase (A_1) and during the postexpansion observation periods both over short- (A_2) and long terms (A_3) demonstrated a significant increase in the maxillary arch width ($P < .001$). The average measurements of the arch length continued to be stable when compared with those from the pretreatment phase (A_1). However, these same values showed a significant reduction of 1.13 mm ($P < .01$) when comparing A_3 with A_2 phases (Table 2).

The mean percentage gain of remaining expansion for the 30 patients at short-term follow-up $A_2 - A_1$ was 17.45 (7.74% to 30.51%) for the lingual points and 11.58 (4.53% to 19.47%) for the occlusal points. The mean percentage residual expansion over a long-term $A_3 - A_2$ was 76.01 (20.82% to 158.06%) for the lingual points and 81.13 (10.20% to 148.22%) for the occlusal points. The amount of tipping of the anchor teeth measured between the lingual points vs the occlusal points is shown in Table 3.

DISCUSSION

Thirty patients with records at all treatment phases were studied. The same individuals were evaluated in the pretreatment phase and after the short- and long-term follow-up. With few exceptions, the majority of studies of maxillary expansion are based on case studies and assessment of small samples.[11,12]

After the overcorrection, the expander appliance was left in situ for an average of five months, and the removable plate was used usually for one year. Few published studies provide information on activation, overcorrection, and retention protocols. Hicks[13] reported that the amount of relapse is related to the retention procedure after expansion. The author confirmed that if the expander was removed immediately after active expansion, the relapse could be as much as 45% of the expansion produced during treatment. Fixed retention for two to three months allowed 10% to 23% relapse, whereas removable retention allowed 22% to 25%. With these results, Hicks concluded that it would be necessary to use fixed retention for at least two months because Zimring and Isaacson[14] demonstrated that the forces that tend to induce relapse continue to act for a period of up to six weeks after active expansion. However, factors such as duration and the type of retention might influence the amount of relapse.

Spillane[15] evaluated the stability of RME in patients treated during the mixed dentition with follow-ups until the eruption of the upper first premolars. Each day an activation of one quarter-turn (0.22 mm) was performed with an unspecific total number of turns of the expander screw. The appliance was used an average of five months (standard deviation of two months). After removal, a retention plate was used for one year or more.

In this study, the mean increase in the transpalatal width was 5.6 mm between the first permanent molars at the level of the gingiva. The results obtained in this study were similar to those of Spillane,[15] who confirmed an average increase of 5.4 mm in the intermolar distance. On the other hand, Moussa et al[16] studied RME cases treated by Haas followed by conventional fixed appliances and found values at the occlusal points, which were different from those of this investigation. He reported a mean increase of 6.7 mm in the intermolar distances compared with our 5.6 mm for the same measure.

Evaluation of alterations of the maxillary arch dimensions over the long term (A_3) was made at the full permanent dentition, approximately four years after the short-term follow-up evaluation (A_2). The dental models from the A_1 phase were compared with those from the A_2 and A_3 phases and among each other. Despite the existence of several short- and long-term studies about RME, its skeletal and dentoalveolar effects on the maxillary arch width are influenced by other types of orthodontic therapies used concurrently. It is important to emphasize that in this study all patients were treated exclusively with RME and no phase 2 appliance treatments using fixed or active removable appliances in either the maxilla or the mandible were used.

In the sample studied, the increase obtained as a clinical response to RME in Class I malocclusion after the first year (A_2) remained after the change to the permanent dentition and four years after (A_3). Moorrees,[17] Moyers et al,[18] and Spillane and McNamara[19] showed that in nontreated individuals the expected increase in the intermolar distance is approximately 0.5 to 1 mm.

Despite the significant reduction after the eruption of the permanent dentition ($P < .001$), at the long-term follow-up evaluation (A_3) the residual expansion continued to be highly significant at 4.26 mm (Table 2), indicating stability of the expansion. These results at long-term follow-up (A_3) surpass those of Moorrees[17] who studied nontreated individuals of the same age range.

The sample was subdivided (short-term and long-term) to determine whether the pretreatment variables had a correlation with the postexpansion stability. In general, the mean percentage of expansion maintained for the total sample over short- and long-terms varied from 50.36% to 105.45%. The mean percentage of expansion was greater at the short-term follow-up (A_2) than at the long-term follow-up (A_3). The percentage of expansion at the first molar at the A_2 phase was 17.45% of the original, with 76% of this remaining at the long-term evaluation A_3. Spillane[15] found 72% of the expansion obtained in the deciduous dentition when measured two years and four months after expansion at the eruption of the first premolars. In this investigation, the percentage expansion rate for this tooth was 22% with a residual of 54% when the measurement was made four years and five months after expansion at the full permanent dentition.

Although a reduction in arch width was observed after expansion, no case of relapse of the posterior crossbite at A_3 was noted. This probably was due to the overcorrection that was performed in all patients. Invariably, there was an increase in the arch width during the transition from the mixed to the permanent dentition in response to the RME. In contrast to Spillane,[15] the results in this study were obtained at a long-term postexpansion without phase 2 appliance treatment and thus the residual expansion was confirmed more accurately.

The maxillary expansion verified in this sample did not cause tipping of the teeth used for anchorage. The increase in the arch width measured at both lingual and occlusal points for the first permanent molars (Table 3) did not present a significant difference. Both distances increased by approximately 5.6 mm. The results suggest that the expansion caused distraction of the maxillary segments plus bodily movement in the anchor teeth (Figure 2), supporting the reports of Herold[20] and Spillane.[15] On the other hand, such findings differ from those of Timms[12] and Adkins et al,[21] who reported dental buccal tipping during expansion. These differences probably reflect the diverse types of protocols including the sample age, design of the expander, amount of screw opening, and finally the method of retention.

The arch length obtained one year after the start of the

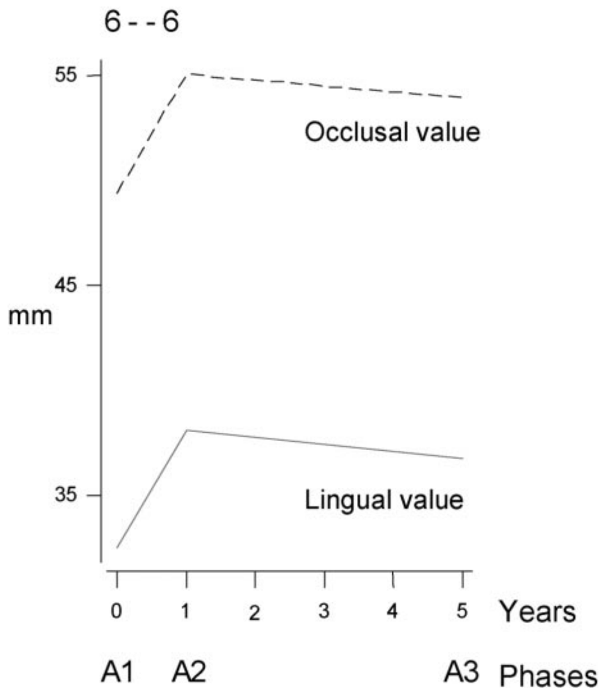

FIGURE 2. Averages of the amount of expansion in the anchor teeth between the lingual points vs the occlusal points obtained at short- and long-term follow-up of the 30 patients.

treatment (A_2), showed a mean postexpansion increase that was highly significant ($P < .001$). The average measurements of the arch length continued to be stable when compared with those from the pretreatment phase (A_1). However, when comparing A_3 with A_2, these same values showed a significant reduction ($P < .01$).

CONCLUSIONS

The long-term clinical response to RME as the only treatment performed in Class I malocclusions demonstrated a significant increase in the postexpansion transpalatal width and a long-term reduction. Although some reduction of the arch width was evidenced after expansion, all the individuals presented a significant increase in this dimension. There was a significant increase in the length of the arch over the short-term and a reduction over the long-term thereby confirming the validity of overtreatment.

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