Original Article

Sagittal and vertical effects of rapid maxillary expansion in Class I, II, and III occlusions

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ABSTRACT

Objective: To evaluate and compare the skeletal vertical and sagittal effects of the Hyrax expander in Class I, II, and III patients.

Materials and Methods: One hundred and eighty-three patients (91 females, 92 males) with a mean age of 8.7 years and with maxillary bilateral cross-bite and maxillary hypoplasia were analyzed retrospectively. They were divided into three groups according to their skeletal class. Sixty-five patients were skeletal Class I, 55 were skeletal Class II, and 63 were skeletal Class III. For each patient a lateral cephalogram was obtained before treatment and at the end of the retention period. Changes in the groups during the observation period were calculated, compared, and statistically analyzed with a *t*-test.

Results: In terms of vertical effects, a statistically significant increase in the anterior vertical dimension was observed only in Class III patients. No statistically significant changes were observed in the posterior vertical dimension in any of the groups. In terms of sagittal effects, in Class I patients the maxilla and the mandible moved forward, but not in a statistically significant way, and the ANB angle showed a statistically significant decrease, but its change was less modified. In Class II patients the maxilla moved forward, but not in a statistically significant way, while the mandible moved forward in all of the patients in a statistically significant manner. The ANB decreased, statistically improving the skeletal classification. In Class III patients the maxilla moved forward in a statistically significant manner; the mandible showed a downward and backward rotation, improving the skeletal classification.

Conclusions: The data obtained in this study permit us to confirm that rapid maxillary expansion can be used in all of the skeletal classes with good vertical and sagittal results. (*Angle Orthod.* 2011;81:298–303.)

KEY WORDS: Rapid maxillary expansion; Maxillary hypoplasia; Hyrax expander

INTRODUCTION

Rapid maxillary expansion (RME) performed in the early stages of maxillary development has become an accepted orthodontic practice when maxillary hypoplasia is diagnosed.[1,2] RME not only separates the midpalatal suture but also affects the circumzygomatic and circummaxillary sutural system.[3] After the halves of the maxillary process have been widened, new bone is deposited in the area of expansion so that the integrity of the midpalatal suture usually is reestablished within 3–6 months.[4] It has been reported that opening of the midpalatal suture has vertical and sagittal effects on both of the jaws. In 1970 Haas[5] showed marked alteration in growth direction and facial morphology as a result of orthopedic therapy. According to many authors,[4–7] the maxilla is frequently displaced downward and forward during maxillary expansion. Other authors[8,9] found only an anterior movement in the maxilla after RME. Da Silva et al.[1] confirmed that the maxilla did not show any statistically significant alterations in the sagittal position over the period of activation of the appliance, while it displayed

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a tendency to rotate downward and backward, increasing the SN-PP angle value. However, Wertz and Dreskin[7] found no significant change in the angulations of the palate with RME therapy. Cleall[10] found unfavorable effects in patients with a well-positioned maxilla. He also reported that in the retention period the maxilla generally returns to its original position. To control the vertical dimension and the facial convexity in Class II malocclusion, Majourau and Nanda[11] describe the application of extraoral forces during RME therapy by the concomitant use of a high-pull chin cap.

In 1993 McNamara, in his study of the effects induced by RME, stated that widening the maxilla led to a spontaneous forward posturing of the mandible during the retention period, correcting the mild Class II relationship.[12,13] The relationship between the transverse dimension and the correction of Class II malocclusion was described by Reichenbach and Taatz[14] in 1971.

These authors present some findings that prove the relationship between the improvement in transverse palatal diameter and the correction of sagittal intermaxillary relationships, and they explained this concept, describing the example of a foot and a shoe, which represented, respectively, the mandible and the maxilla. If shoe is too small, the foot will not slide fully into the shoe. If shoe is wider, the foot slides forward into a comfortable position.[14] This example allows us to understand how palatal transverse expansion solves spontaneous mandible repositioning in a forward position, solving or improving sagittal malocclusion.

In 1889, Kingsley[15] underlined this phenomenon, pointing out how the transverse expansion could favor mandible advancement. Moreover, he underlined how this phenomenon is frequent and can be evaluated in treating patients with mixed dentition. He calculated that skeletal Class II patients with a transverse maxillary diameter of less than 31 mm (measured between the upper first molars) obtain benefit from a palatal expansion in order to gain a correct mandible position.

Bishara et al.[16] underlined that in comparing skeletal Class I patients with skeletal Class II division II patients who have not been orthodontically treated, the second group presents a maxillary and mandible transverse diameter reduction.

McNamara[12] held that it is important to consider the transverse plane prior to the diagnosis of a Class II malocclusion. RME also leads to a spontaneous occlusal correction of skeletal Class III. This phenomenon seems to be a paradox because it leads to the correction of the skeletal Class II occlusion as well. It also aids in the correction of a skeletal Class III occlusion, although through a different action. In fact, after a rapid palatal expansion, thanks to the activation of the circummaxillary suture, a maxillary movement downward and forward can be observed. This translation allows for correction of the skeletal Class III occlusion with maxillary retrusion. A slight mandible clockwise rotation aids in the resolution of the sagittal discrepancy.

It is important to underline that the correction of skeletal Class III occlusion happens during the active phase of therapy, while the correction of skeletal Class II occlusion happens during the retention phase. It has been observed[1,4,6,7,17–19] that maxillary expansion has different effects in Class I, II, and III malocclusions.

There is not unanimous agreement within the literature[14,20–23] with regard to the long-term stability of the results obtained by RME. Cozza et al.[13] underlined that modest short-term changes can be reversible.

Lima Filho and de Oliveira Ruellas[20] obtained long-term stability (10 years after orthodontic treatment) of the results obtained by RME and SPE in the correction of skeletal Class II malocclusion. Maspero et al.[21,22] evaluated the consequences of rapid palatal expansion on breathing. The effect of expansion consists of a downward and forward movement of the nose maxillary complex, from which an increase in all of the nasal cavity diameters derives.[22]

It is difficult to compare the results obtained from different studies because of the variety in cephalometric analysis, type of growth pattern, and patient age.[13] The aim of this study is to analyze the vertical and sagittal effects of RME in Class I, II, and III malocclusions and to compare these effects between the groups.

MATERIALS AND METHODS

The sample for this retrospective study included 183 patients (mean age, 8.7 years; 91 females, 92 males; 65 skeletal Class I subjects, 55 skeletal Class II subjects, and 63 skeletal Class III subjects) with maxillary bilateral cross-bite.

The inclusion criteria were as follows:

- No history of orthodontic treatment;
- Growing patients;
- Pretreatment and posttreatment lateral x-ray with excellent contrast;
- Transverse maxillary hypoplasia; and
- Presence of bilateral posterior cross-bite.

Exclusion criteria were as follows:

- Congenital anomalies;
- Previous orthodontic treatment;
- Facial or dental asymmetries; or
- Dental anomalies.

Table 1. Changes in Class I Patients[a]

	Age, y	Pre							Post						
		SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.GO	SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.GO
Average	9.2	79.92	77.45	2.47	9.3	33.33	110.21	63.96	80.17	78.04	2.13	10.08	33.83	110.6	64.52
SD	1.7	1.64	1.63	0.83	2.13	4.14	2.87	3.21	1.76	1.84	0.9	2.08	4.33	2.8	3.26
Test *t*		0.4	0.05	0.03	0.04	0.5	0.43	0.33							
Variation		0.25	0.59	−0.34	0.78	0.5	0.39	0.56							

[a] SD indicates standard deviation.

Class II patients were considered if their ANB angles were greater than 4°, and Class III patients were considered if their ANB angles were less than 0°.

Lateral cephalograms were taken by the same technician and manually traced by one operator and verified for landmark location and anatomic contours by a second operator. Any disagreements were solved by retracing the landmark or structure to the mutual satisfaction of both of the operators. Lateral cephalograms were traced using acetate paper. The assessment of the skeletal relationship was based on SNA-SNB and ANB angles. SN-SNP.SNA, SN-GO.GN, N.Me, and S.GO were also analyzed.

To exclude intraoperator error, each measurement was repeated by the same operator after a period of 7 days had elapsed. All of the patients were treated with the Hyrax expander to correct the transverse dimension.

A lateral cephalogram was taken before treatment (T0) and a second one was taken after retention (T1). No other treatment took place during the period extending from T0 to T1. The Hyrax screw was activated twice per day, with one quarter turn in the morning and one in the evening for 15 days. The appliance was left in place in a passive state for 6 months. The patients were controlled weekly until overcorrection was obtained. The average differences at the beginning and at the end of treatment were evaluated with a *t*-test.

RESULTS

Measurements from T0 and T1 lateral cephalograms for each group are shown in Tables 1–3. The cephalometric values before T0 and T1 showed significant changes in each group.

Changes in Class I Patients

The RME procedures induced statistically significant alterations in Class I patients only in two cephalometric measurements: SN-SNP.SNA (+0.78) and ANB (−0.34). The increase of SN-SNP.SNA resulted in a downward and backward rotation of the palatal plane, which was also responsible for the decrease in ANB angle (Table 1).

Changes in Class II Patients

In Class II patients the RME procedures induced statistically significant modifications in the following measurements: SNB (+2.25), ANB (−1.81), and SN-SNP.SNA (+0.97). As described for Class I patients, the increase in SN-SNP.SNA resulted in a downward and backward rotation of the palatal plane. The increase in SNB was due to a forward position of the mandible. The ANB angle decreased statistically as a result of the forward position of the mandible, improving the skeletal class, and the backward rotation of the palatal plane. No increase in the anterior vertical dimension was noted, but a mild decrease in N-Me was noted (−0.24) (Table 2).

Changes in Class III Patients

The RME procedures induced statistically significant alterations in five cephalometric measurements: SNA (+0.81), SNB (−1.35), ANB (+2.16), SN-SNP.SNA (+1.33), and N-Me (+0.84). SNA increased as the result of an anterior movement of the maxilla. SNB decreased as a result of the downward and backward rotation of the mandible. The increase in SNA angle and the decrease in SNB angle contrib-

Table 2. Changes in Class II Patients[a]

	Age, y	Pre							Post						
		SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.Go	SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.Go
Average	8.8	79.88	74.02	5.86	9.65	32.41	110.48	64.95	80.32	76.27	4.05	10.62	33.2	110.24	65.43
SD	1.4	1.79	2.08	1.03	1.75	3.43	3.19	1.88	1.63	1.79	1.28	1.68	3.53	3.15	1.87
Test *t*		0.18	0	0	0	0.24	0.69	0.18							
Variation		0.44	2.25	−1.81	0.97	0.79	−0.24	0.48							

[a] SD indicates standard deviation.

Table 3. Changes in Class III Patients[a]

		Pre							Post						
	Age, y	SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.Go	SNA	SNB	ANB	SN-SNP.SNA	SN-GO.GN	N.Me	S.Go
Average	8.1	78.06	80.77	−2.71	9.14	31.16	111.21	64.76	78.87	79.42	−0.56	10.47	31.72	112.05	65.44
SD	1.5	2.03	1.82	1.23	2.02	4.73	1.89	2.69	2.29	2.09	1.4	1.94	4.68	1.8	2.72
Test *t*		0.04	0	1.06	0	0.5	0.01	0.16							
Variation		0.81	−1.35	2.16	1.33	0.56	0.84	0.68							

[a] SD indicates standard deviation.

uted to the improvement of ANB, which increased in a statistically significant manner. In addition, in Class III patients a downward and backward displacement of the palatal plane that was statistically significant was observed. An increase in the anterior total facial height, N-Me, was also noted, and this caused the downward and backward rotation of the mandible (Table 3).

Comparison Between the Three Groups

In all of the three groups, SN-SNP.SNA increased in a statistically significant manner. ANB showed a different statistically significant variation among the groups. In Class I and II patients, ANB decreased, while in Class III patients it increased. SNA increased in a statistically significant manner only in Class III patients. SNB increased in a statistically significant manner in Class II patients and decreased in Class III patients. No statistically significant modifications were found for Class I patients. A statistically significant increase in the anterior vertical dimension (N-Me) was found only in Class III patients as a result of a downward and backward rotation of the mandible, confirmed by the statistically significant increase in SN-GO.GN. No statistically significant modifications of SN-GO.GN were observed in Class I and II patients. No statistically significant differences were found in the posterior vertical dimension (S-Go) in any of the three groups.

DISCUSSION

Many authors[6,7,9,10,13,18,23,24] have found significant sagittal and vertical changes with RME treatment procedures. In this study, sagittal and vertical modifications in Class I, II, and III growing patients after RME were analyzed.

The data permit us to underline that Class II malocclusions have a strong transverse component. In fact, the expansion of the maxilla disrupts the occlusion determining a slight forward position of the mandible, improving the sagittal occlusal relationship. McNamara[12] suggested that the teeth themselves act as an endogenous functional appliance, encouraging a change in mandibular posture and subsequently a change in the maxillary-mandibular occlusal relationship. According to the same author, this phenomenon usually happens during the first 6–12 months of the post-RME period as a result of the gradual repositioning of the lower jaw. Data obtained in this study confirm this theory. In fact, in all of the Class II patients a statistically significant decrease in the ANB angle was obtained during treatment as the result of a statistically significant increase in the SNB angle.

These data indicate that in skeletal Class II subjects, the constricted maxillary bone impedes physiological sagittal mandibular growth. When the maxillary bone can't develop normally in the transverse plane as the result of an anomalous function (tongue position, oral breathing), it enhances its development in the vertical plane, with a consequent backward and downward position of the mandible and insufficient and abnormal growth of the nasal septum, which is often deviated. Palatal expansion increases transverse maxillary diameter and releases the mandible, which gains a correct sagittal position.

In a recent study, Volk et al.[25] concluded that maxillary expansion does not predictably improve dental Class II relationship. However, in the study in which 13 Class II patients treated by RME were considered, seven of them improved the dental Class II occlusion as well (if not in a statistically significant manner).[25] The discrepancy between the results obtained in our study and those of Volk et al. is due to the distinct methodologies used.

In the study presented in this article we analyzed the skeletal cephalometric response of RME in the sagittal and vertical planes. The study of Volk et al.[25] considered the occlusal relationship, in which cast models were mounted in the articulator in centric occlusion and in maximum intercuspation. In addition, in skeletal Class III patients a significant anterior movement of the maxilla was found. This change agrees with the findings in the studies of Wertz,[6] Cleall,[10] Linder-Aronson and Lingren,[18] Davis and Kronman,[24] Hicks,[26] and Gardner and Kronman.[27]

Gardner and Kronman[27] underlined that opening the spheno-occipital synchondrosis could be responsible for the forward displacement of the maxilla. This change happens in the active phase of treatment. The ANB increased by 2.16°; this could be related to the anterior displacement of the maxilla (SNA increased by a statistically significant measure of +0.81°) and the posterior rotation of the mandible. This is in agreement with the findings of Haas[4,5] and Wertz.[6] However, Haas reported that after treatment the maxilla will partially or completely return to its original position. In this group of patients a slight, but not statistically significant, increase in the mandibular plane angle (SN-Go.Gn) was found. These data agree with the findings of Wertz,[6] who noted that the increase in the mandibular plane angle could be accompanied by a decrease in the SNB angle. A downward and backward displacement of the apical base (SNB) results in a statistically significant rotation of the palatal plane (SN-SNP.SNA) and a slight but not statistically significant rotation of the mandibular plane (Sn-Go.Gn). The increase in the mandibular plane is responsible for the increase in anterior facial height, N-Me, in this group of patients.

In Class I patients a slight but statistically significant decrease in the ANB angle and an increase in the palatal plane were found. No other statistically significant modifications of the cephalometric measurements studied were found. In all of the patients in each group SN-SNP.SNA increased as a result of a downward and backward displacement of the palatal plane. The mandibular plane did not show a statistically significant change after RME procedures, as did the posterior vertical dimension (S-Go) in all of the groups.

CONCLUSIONS

- In relation to cranial base, the maxilla moved forward in a statistically significant manner only in Class III patients.
- The mandible showed a downward and backward rotation only in Class III patients, whereas in Class II patients it showed a statistically significant increase as a result of a forward movement.
- The palatal plane displayed a downward and backward rotation after RME in all of the patients.
- A statistically significant increase in the anterior total facial height (N-Me) was observed only in Class III patients.
- No statistically significant changes were observed in the posterior vertical dimension. RME procedures permit us to obtain the resolution of the maxillary hypoplasia. The data obtained in this study permit us to underline the fact that RME can be used in all of the skeletal classes, with good vertical and sagittal results.

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