Rapid palatal expansion: a comparison of two appliances

Amanda do Prado Rodrigues[a]
André da Costa Monini[b]
Luiz Gonzaga Gandini Jr[b]
Ary dos Santos-Pinto[b]

[a] Private practice, São Paulo, SP, Brazil.

[b] Department of Pediatric Dentistry, Araraquara School of Dentistry, State University of São Paulo - UNESP, Araraquara, SP, Brazil.

Abstract: This study analyzed occlusal radiographs to compare the transverse changes produced in patients treated with rapid maxillary expansion using two types of appliances. The sample consisted of 31 children aged 7 to 10.6 years, of both genders, with posterior cross-bite. Fifteen children were treated with a tooth-borne expander and 16 were treated with a tooth-tissue-borne expander. Occlusal radiographs obtained at treatment onset and at the end of the retention period were digitized. The following variables were measured: intermolar distance (IMD), interapical distance (IApD), interbase distance (IBaD) and interarm distance (IArD). The results revealed increases in all measurements in both groups after rapid maxillary expansion. Comparison between groups revealed that the increases were greater in patients treated with the tooth-borne expander, except for the IArD measurement, which presented the same increase in both groups. Even though the IMD measurements differed between expanders, they were proportional to the activation of the appliances (IBaD). The increase in the IApD measurement was proportionally greater in the group treated with the tooth-borne expander (0.7:1.0) than in that treated with the tooth-tissue-borne expander (0.4:1.0). It was concluded that both appliances had similar effects, although the tooth-tissue-borne expander produced a lesser opening at the apical region of the incisors.

Descriptors: Malocclusion; Palatal Expansion Technique; Radiography, Dental; Dental Arch.

Introduction

Transverse maxillomandibular discrepancies are a major cause of several malocclusions. This type of malocclusion may be corrected in different manners, including slow expansion,[1-3] rapid expansion[4-6] and surgically assisted expansion.[7,8] Most rapid maxillary expansion treatments employ fixed tooth-tissue-borne and tooth-borne expanders. Rapid maxillary expansion is characterized by a widening of the midpalatal suture produced by forcing a lateral shift of the two horizontal processes of the maxilla.[9] The difference between the tooth-borne and the tooth-tissue-borne appliances is that the latter appliance has acrylic plates which cover the palatal mucosa bilaterally, and on which an 11-mm screw is fixed (Figure 1), and which further aid in improving the anchorage provided by the two bands placed on the first permanent molars. The tooth-tissue-borne appliance is often called a Haas-type expander (a reference to the author that introduced the appliance), and the tooth-borne appliance is called a Hyrax-type expander (an abbreviation of "hygienic rapid palatal expander appliance"). The objective of these appliances is to correct

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Corresponding author:
Ary dos Santos-Pinto
E-mail: *spinto@foar.unesp.br*

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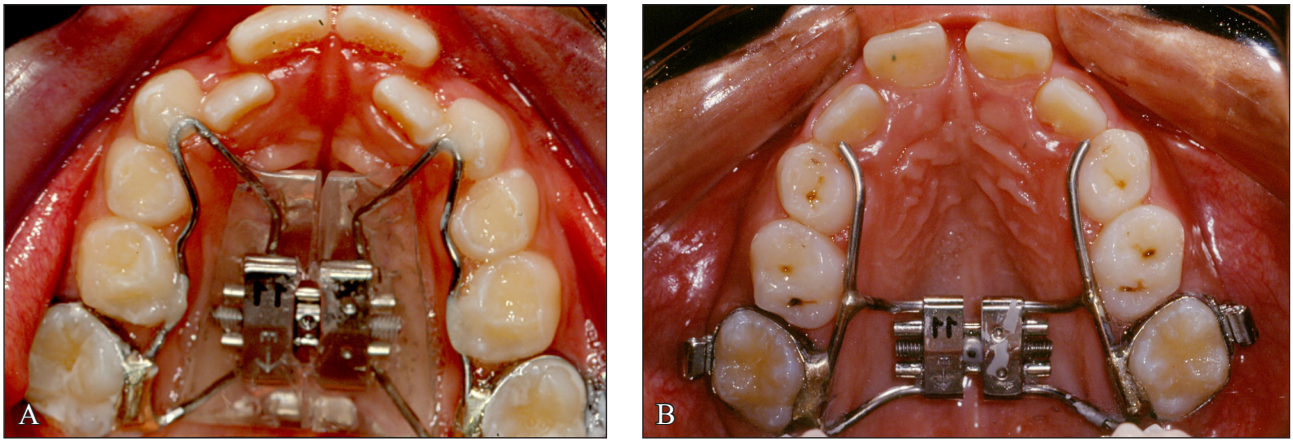

Figure 1 - Tooth-tissue-borne (A) and tooth-borne expanders (B).

the transversal discrepancy of the upper arch by opening the medial palatal suture of the maxilla by rapid activation of the appliance screw, twice a day.

Several studies have been conducted on rapid maxillary expansion (RME). More than 600 papers may be retrieved searching the acronym RME in the Pubmed database. Notwithstanding, few comparative studies to date have been conducted between these two main expanders.[10-13] Therefore, the aim of this prospective clinical study was to compare the effects of the tooth-tissue-borne and the tooth-borne expanders by analyzing occlusal radiographs before and after RME.

Table 1 - Demographics of the study sample.

	Tooth-tissue-borne expander	Tooth-borne expander
n	16	15
Gender		
Male	7	8
Female	9	7
Age (years)		
Mean	8.06	7.46
Minimum	7	7.08
Maximum	10	10.58

Methodology

This study was approved by the Research Ethics Committee, Araraquara School of Dentistry, State University of São Paulo (FOAr-UNESP). The sample consisted of 31 children of both genders, aged 7 to 10.6 years, presenting unilateral or bilateral posterior crossbite, in the mixed dentition stage. These children presented no early loss of posterior teeth, caries, periodontal disease, or craniofacial or growth disorders. The children were matched by gender and age, and were divided into two groups:

- Group 1 was composed of 15 children treated with a tooth-borne expander, and
- Group 2 was composed of 16 children treated with a tooth-tissue-borne expander (Table 1).

The appliances were constructed using bands only on the permanent first molars, and 11-mm screws (Morelli, Sorocaba, Brazil). The extensions of the appliances were bonded to the lingual aspects of the deciduous molars and canines with Concise resin (3M, Monrovia, USA). The appliances were activated by three turns of the screw on the same day they were placed (0.25 mm per turn, 0.75 mm per day), and then activated twice a day (0.25 mm per turn, 0.5 mm per day) by the patient. The active phase of expansion was monitored weekly until the buccal segments were overcorrected by half a cusp. Afterwards, all appliance screws were tied off with a ligature wire, and the appliances were retained for approximately three months before removal.

Occlusal radiographs were obtained at treatment onset and at the end of the retention period, with the Camper plane parallel to the ground, and the long X-ray cone at a 60-degree angle to the film and parallel to the patient's midline. The occlusal radiographs were digitized using an Agfa scanner (Snap-scan 1236; Agfa, Mortsel, Belgium), and the measurement values analyzed in the study were obtained using Radiocef Studio

version 4.0 software (Radio Memory Ltda., Belo Horizonte, Brazil). The following variables were measured:

- intermolar distance (IMD) - the distance between the most anterior and most external border of the tube on either maxillary first molar;
- interapical distance (IApD) - the distance between the apices of the maxillary central incisors;
- interbase distance (IBaD) - the distance between the two halves of the appliance screw; and
- interarm distance (IArD) - the distance between the arms of the appliance anterior extensions (Figure 2).

Distortions in the IApD and IBaD measurements were mathematically corrected based on the degree of magnification observed between the actual size of the appliance screw and its radiographic image. The other transversal measurements did not require correction because the actual reference structures were very close to the radiographic film.

Dependent t-tests were used to compare each variable in the two stages within the same group, and independent t-tests were used to compare the variable changes between groups, at a significance level of 5%. Casual and systematic errors were calculated comparing the first and the second measurements with Dahlberg's formula and the dependent t-test, respectively, at a significance level of 5%. The casual error ranged from 0.09 mm (IBaD) to 0.26 mm (IApD), and the systematic error showed no difference.

Results

The results revealed an increase in all measurements, in both groups (Table 2).

Comparison between both groups (Table 3) evidenced statistically significant differences for all variables, except for the IArD, which increased 6.8 mm using the tooth-borne expander, compared to 5.6 mm using the tooth-tissue-borne expander. The increase in the IMD was greater in individuals treated with the

Figure 2 - Measurements analyzed in the study.

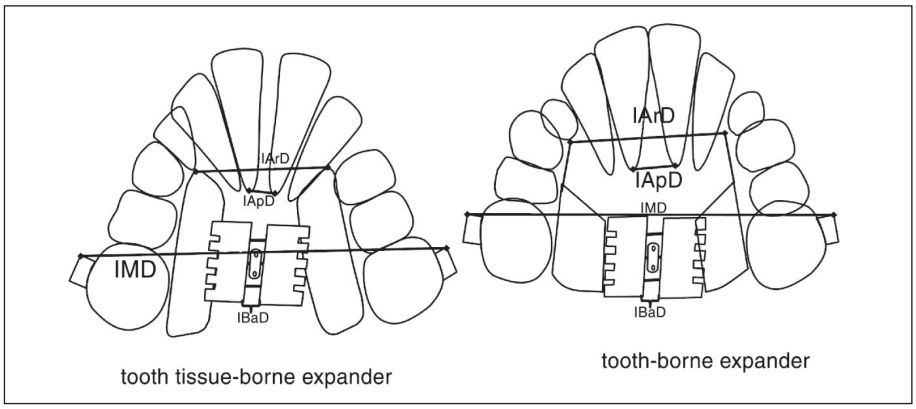

Table 2 - Rapid maxillary expansion: mean and standard deviation of the measurements made on pre-treatment (initial) and post-treatment (final) occlusal radiographs (dependent t-test).

Variable	Group	Pre-expansion		Post-expansion		Difference		p
		Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	
IMD	Tooth-borne expander	55.14	3.4	62.50	2.9	7.35	2.0	*
	Tooth-tissue-borne expander	55.14	2.7	60.94	2.8	5.80	1.1	*
IBaD	Tooth-borne expander	2.41	0.4	10.22	1.2	7.81	1.3	*
	Tooth-tissue-borne expander	1.99	0.2	7.89	1.2	5.90	1.1	*
IArD	Tooth-borne expander	23.12	1.9	29.90	2.9	6.78	2.2	*
	Tooth-tissue-borne expander	21.91	1.8	27.56	1.9	5.64	1.0	*
IApD	Tooth-borne expander	6.47	1.4	11.97	2.1	5.50	2.0	*
	Tooth-tissue-borne expander	6.97	1.0	9.54	1.8	2.56	1.2	*

* $p < 0.001$

Table 3 - Results of the comparison (independent t-test) between the changes observed after rapid maxillary expansion using a tooth-tissue-borne and a tooth-borne expander.

Variable	Group	Mean (mm)	Difference (mm)	SD
IMD	Tooth-borne expander	7.35	1.55*	2.0
	Tooth-tissue-borne expander	5.80		1.1
IBaD	Tooth-borne expander	7.81	1.91**	1.3
	Tooth-tissue-borne expander	5.90		1.1
IArD	Tooth-borne expander	6.78	1.14	2.2
	Tooth tissue-borne expander	5.64		1.0
IApD	Tooth-borne expander	5.50	2.94**	2.0
	Tooth-tissue-borne expander	2.56		1.2

* $p < 0.05$; ** $p < 0.01$

Table 4 - Mean and standard deviation of the proportion between screw activation and changes promoted by rapid maxillary expansion.

Proportion	Group	Mean	SD	Min.	Max.
IMD / IBaD	Tooth-borne expander	1.0	0.2	0.3	1.2
	Tooth-tissue-borne expander	1.0	0.1	0.9	1.1
IArD / IBaD	Tooth-borne expander	0.9	0.2	0.3	1.2
	Tooth-tissue-borne expander	1.0	0.1	0.9	1.2
IApD / IBaD	Tooth-borne expander	0.7*	0.2	0.3	1.0
	Tooth-tissue-borne expander	0.4*	0.2	0.1	0.7

* $p < 0.01$

tooth-borne expander (7.4 mm) than in those treated with the tooth-tissue-borne expander (5.8 mm). The interbase distance (IBaD) increased an average of 7.7 mm using the tooth-borne expander, a greater increase than that achieved using the tooth-tissue-borne expander (5.8 mm). The increase in the IApD was greater for the tooth-borne expander (5.4 mm) than for the tooth-tissue-borne expander (2.5 mm).

Even though the IMD measurements differed between expanders, they were proportional to the activation of the appliances (IBaD) (a ratio of approximately 1:1 was maintained). A proportionally greater increase of the interapical distance (IApD) was observed in the tooth-borne expander group (0.7:1.0) compared to the tooth-tissue-borne expander group (0.4:1.0) (Table 4, Figure 3).

Discussion

The occlusal radiograph has the advantage of allowing both an analysis of transversal changes in the dental arches and an evaluation of the skeletal effect of an appliance, by enabling observation of the midpalatal suture opening. Opening of the suture may be indirectly quantified by measuring the separation observed between the apices of the central incisors, which are displaced by the bone movement of the hemi-maxillae. In this study, the distortions of the radiographic images of reference structures were corrected. Structures that were distant from the radiographic film, such as the expanding screw and the incisor apices, underwent image magnification by the radiographic technique. Therefore, the IApD and IBaD measurements were corrected using the actual size of the expanding screw compared to that obtained in the occlusal radiographs as a reference.[9,14] Because the points located on the molars and on the metallic anterior extension of the appliances were very close to the radiographic film, their images were not magnified and thus required no correction.

Our results demonstrated that the treatments performed with the tooth-tissue-borne and tooth-borne expanders promoted a transversal increase of the maxilla and separation of the midpalatal suture, as also demonstrated by other authors.[4-6,9,11,13-16] There was a greater increase in the IMD measurement in patients treated with the tooth-borne expander (7.4 mm) compared to patients treated with the tooth-tissue-borne expander (5.8 mm),

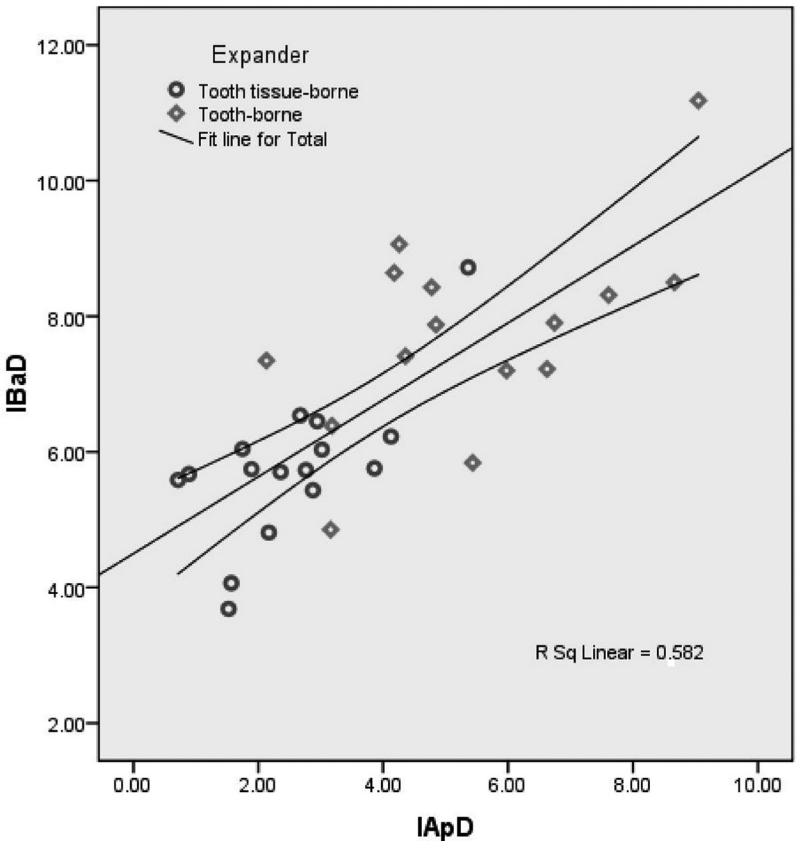

Figure 3 - Relationship between amount of activation (IBaD) used for the tooth-borne and tooth-tissue-borne expanders, and amount of apical separation of the maxillary central incisors (IApD).

and this difference was statistically significant. Other studies also observed similar outcomes,[10] but the differences were not statistically significant in these studies.[11,12] Our results suggest that a greater expansion between molars is achieved when a tooth-borne expander is used. However, some authors have observed different outcomes, specifically, a greater increase achieved by the tooth-tissue-borne expander compared to that achieved by the tooth-borne expander.[13]

With regard to the IApD measurement, the increase was twice as great for the tooth-borne expander (5.4 mm) compared to that observed for the tooth-tissue-borne expander (2.5 mm). This result disagrees with that of other authors[12] and suggests a greater opening of the suture in the anterior region when the tooth-borne expander is used.

Measurement of the IBaD revealed a greater opening of the expanding screw in the tooth-borne expander (7.7 mm) compared to the tooth-tissue-borne expander (5.8 mm). This difference in appliance activation may have accounted for the differences found in the measurements analyzed, hence the importance of analyzing the measurement changes observed in relation to the extent of opening of the expanding screw.[17] Among the studies found in the related literature comparing the two appliances, only one[11] standardized the activations, whereas the others did not mention the relationship between the amount of activation and its effects.[10,12,13] Bearing this in mind, our analysis revealed an approximate ratio of 1:1 between the opening of the expanding screw and the IMD and IArD measurements, demonstrating that both appliances promoted an increase in width in the maxillary arch, similar and proportional to the appliance activation. Regarding the IApD measurement, the ratio was 0.7:1 for the tooth-borne expander and 0.4:1 for the tooth-tissue-borne expander, indicating a separation of the apices of the central incisors —or opening of the midpalatal suture—of nearly 70% and 40%, respectively, in relation to expander activation. This result reflects a greater opening in the maxillary anterior region effected by the tooth-borne expander compared to the tooth-tissue-borne expander.

The results of this study highlight the importance of analyzing the extent of rapid maxillary expansion

achieved by the appliances studied, taking into account the amount of activation of the expanding screw.[11,15] Even though the measurement changes caused by the treatment were greater for the tooth-borne expander, interpretation of the results changed when the results were analyzed in relation to the activation applied. The differences found in the midpalatal suture opening ratios (i.e., separation of the apices of the incisors) may have been influenced by the amount of activation of the expanding screw. That is to say, the orthopedic and orthodontic effects of these appliances may depend on the extent to which the expanding screw is opened.[15] Further studies are warranted to assess the differences between these appliances and also to determine whether the amount of activation influences the results.

Conclusion

We recommend that the results of rapid maxillary expansion achieved by expanders be analyzed taking into account the amount of screw activation.

Analyzing the results of this clinical study and considering the amount of screw activation, it was concluded that the increase in the intermolar distance was similar for both appliances; however, the opening of the incisors interapical distance was greater in patients treated with the tooth-borne expander than in those treated with the tooth-tissue-borne expander.

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