

Rapid Maxillary Expansion—Tooth Tissue-Borne Versus Tooth-Borne Expanders: A Computed Tomography Evaluation of Dentoskeletal Effects

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Abstract: This study evaluated rapid maxillary expansion (RME) dentoskeletal effects by means of computed tomography (CT), comparing tooth tissue–borne and tooth-borne expanders. The sample comprised eight girls aged 11 to 14 years presenting Class I or II malocclusions with posterior unilateral or bilateral crossbite that were randomly divided into two treatment groups, palatal acrylic (Haas-type) and hygienic (Hyrax) expanders. All appliances were activated up to the full seven mm capacity of the expansion screw. The patients were subjected to a spiral CT scan before expansion and after a three-month retention period when the expander was removed. One-millimeter-thick axial sections were scanned parallel to the palatal plane, comprising the dentoalveolar area and the base of the maxilla up to the inferior third of the nasal cavity. Multi-planar reconstruction was used to measure maxillary transverse dimensions and posterior teeth inclination by means of a computerized method. The results showed that RME produced a significant increase in all measured transverse linear dimensions, decreasing in magnitude from dental arch to basal bone. The transverse increase at the level of the nasal floor corresponded to one-third of the amount of screw activation. Tooth-borne (Hyrax) and tooth tissue–borne (Haas-type) expanders tended to produce similar orthopedic effects. In both methods, RME led to buccal movement of the maxillary posterior teeth, by tipping and bodily translation. The second premolars displayed more buccal tipping than the appliance-supporting teeth. The tooth tissue–borne expander produced a greater change in the axial inclination of appliance-supporting teeth, especially first premolars, compared with the tooth-borne expander. (*Angle Orthod* 2005;75:548–557.)

Key Words: Maxillary expansion; Computed tomography; Palate

INTRODUCTION

In an attempt to normalize the constricted maxillary dental arch, rapid maxillary expansion (RME) is a routine clinical resource in current mechanotherapy. It in-

creases the dental arch perimeter¹ by means of mid-palatal suture splitting and simultaneously matching both dental arches transversely.²

Two types of appliances for RME are most widely recognized in the literature, and the main difference between them is the presence or absence of an acrylic pad close to the palate. The tooth tissue–borne or Haas-type expander possesses this acrylic pad and is assumed to distribute the expanding force between the posterior teeth and the palatal vault. The tooth-borne or Hyrax expander does not include the acrylic pad and presumably delivers the force to the maxilla only by means of the appliance-supporting teeth.

Even though cephalometric and dental cast investigations have not demonstrated differences between the tooth-borne and tooth tissue–borne expanders,^{3–5} there is no consensus in the literature regarding the differences between the mode of action of the two appliances. The easier hygiene, greater comfort, and

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prevention of lesions to the palatal mucosa are the advantages of the hygienic appliance.⁶ On the other hand, the palatal acrylic expander is stated to be the only appliance that might lead to a significant expansion of the maxillary base.⁷⁻¹¹ Moreover, the absence of an acrylic pad is stated to allow relapse of the orthopedic effect during the retention stage.¹⁰ Because the tooth-borne expander maintains only the dental arch expansion, the "bone would move through the teeth."¹⁰ No evidence has confirmed such assumptions.

The use of computed tomography (CT) allows measurement of transverse dimensions in any area of the maxilla, as well as changes in axial inclination of the posterior teeth, by means of reproduction of a real maxillary section in all three planes.^{12,13} Therefore, the aim of this study was to quantify and compare the dentoskeletal effects of RME produced by the tooth tissue-borne and tooth-borne expanders by means of CT in order to clarify the abovementioned controversies.

MATERIALS AND METHODS

This project was approved by the Ethical Committee at Bauru School of Dentistry, University of São Paulo, and informed consent was obtained from the parents or guardians of all patients. The sample was selected by examination of 87 young subjects presenting with Class I or II division 1 malocclusion with unilateral or bilateral posterior crossbite who sought orthodontic treatment at the institution. The exclusion criteria were age below 11 and above 14 years, persistence of any primary tooth, absence of maxillary posterior permanent teeth, metallic restorations on the maxillary posterior teeth, previous periodontal disease, previous orthodontic treatment, and male sex. This led to a sample of eight patients, who were randomly assigned to two groups:

Group I

The tooth tissue-borne expander group consisted of four female patients with a mean age of 12.4 years (11.4 to 13.6 years). This group was treated by RME using a tooth tissue-borne expander (Figure 1A) before fixed appliance mechanotherapy. The 7-mm screw (Dentaurum, Ispringen, Germany) was activated with a complete turn after placement, followed by one-quarter turn in the morning and one-quarter turn in the evening in the following days⁷ up to locking, on the 16th day (0.8 mm per complete turn). Thus, the expansion screw was activated exactly 7 mm in all patients. After the active expansion phase, the appliance was kept as a retainer for three months.

Group II

The tooth-borne expander group consisted of four female patients with a mean age of 12.6 years (11.5 to 13.9 years). This group was treated by RME with a tooth-borne expander previous to fixed appliance mechanotherapy (Figure 1B). During the active expansion stage, the same 7-mm screw was activated as described for group I.

All patients were subjected to CT imaging before expansion and after a three-month retention period when the expander was removed. A spiral CT machine model Xvision EX (Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan) was used at 120 kV and 100 mA, with a scanning time of one second per section. A FC 30 scanning filter with a field of view of 12.6 × 12.6 cm and matrix of 512 × 512 pixels was used. The window width was 2400 HU with a center of 1300 Hu, (Hounsfield).

The perpendicular light beam resource provided by the machine was used in an attempt to standardize the head position allowing comparison of the images achieved before and after expansion. For that purpose, the patient was positioned lying on the table with Camper's plane perpendicular to the ground, with the longitudinal light beam passing through the center of glabella andiltrum, and the transverse light beam passing through the lateral eye canthus (Figure 2). One-millimeter-thick axial sections were performed parallel to the palatal plane, comprising the dentoalveolar and basal areas of the maxilla, up to the lower third of the nasal cavity.

The data were transferred to a network computer workstation with Alatoview software (Toshiba Corporation Medical Systems Company) on which two-dimensional reformatted images were generated and measured by the computerized method.

Transverse dimensions of the maxilla were measured on the coronal images perpendicular to the midsagittal plane, through the center of the palatal root of the right first premolar and first molar. Figures 3 and 4 illustrate the linear variables obtained on each of these two images both before and after expansion.

The analysis of maxillary posterior teeth axial inclination was conducted on the orthoradially reformatted images perpendicular to the contour of the dental arch, through the center of the palatal root of the first premolars and molars and center of the root of the second premolars on both sides. Figure 5 illustrates the angular variable obtained on each of these images.

Statistical analyses

All measurements were performed twice, with a month interval, by the same calibrated examiner. Statistical analyses were performed taking into account

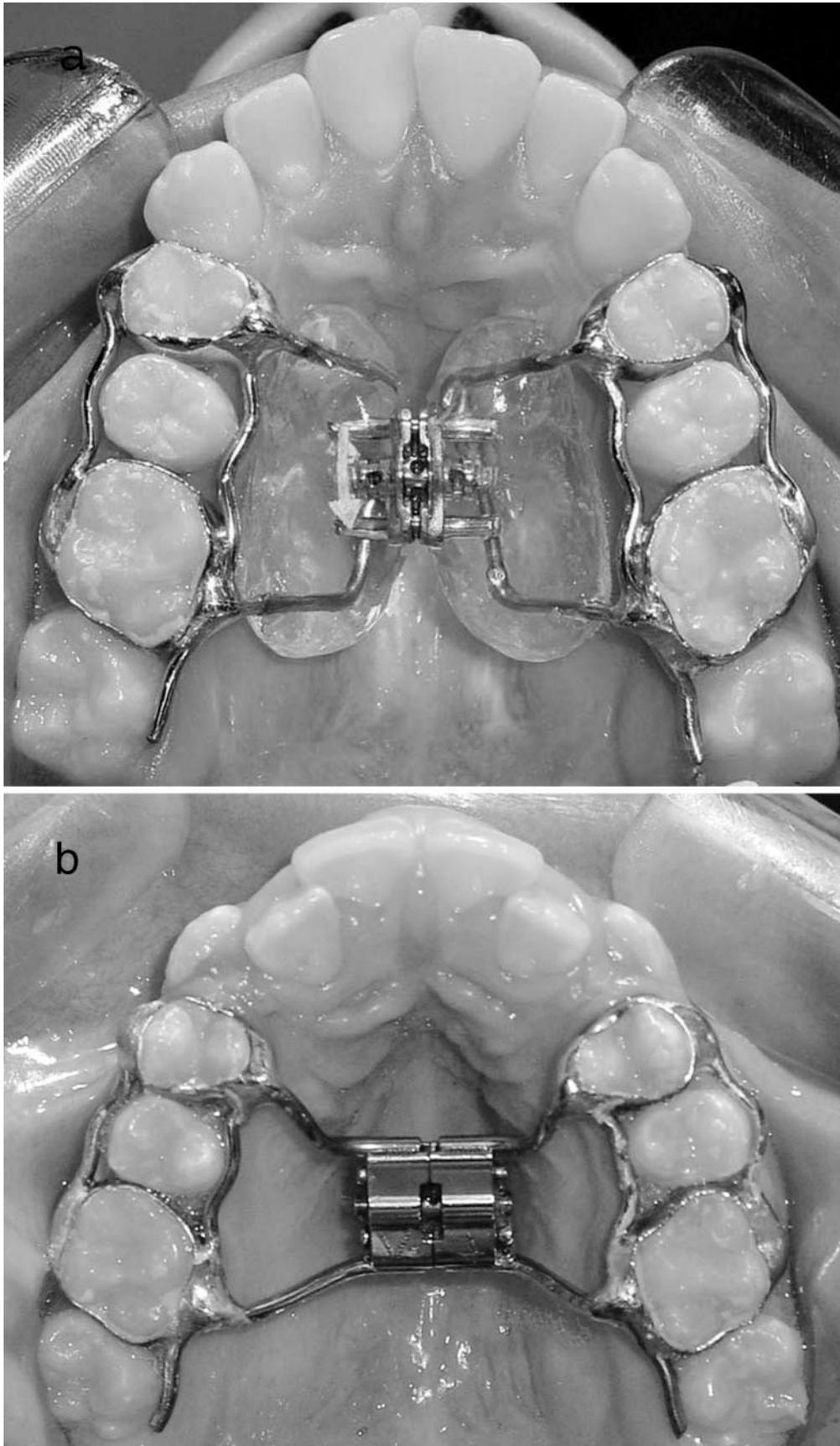


FIGURE 1. (A) Tooth tissue-borne expander. (B) Tooth-borne expander.

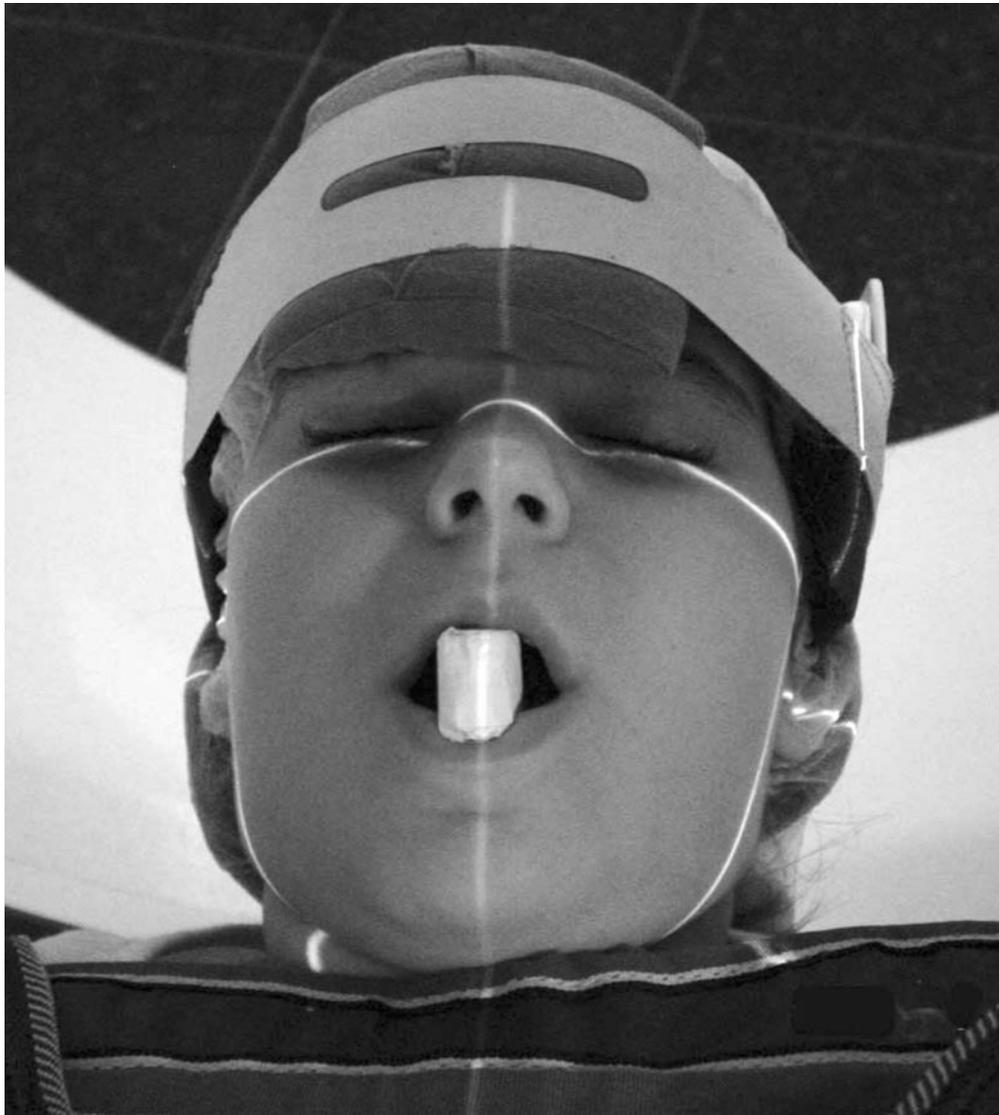


FIGURE 2. Standardized head position.

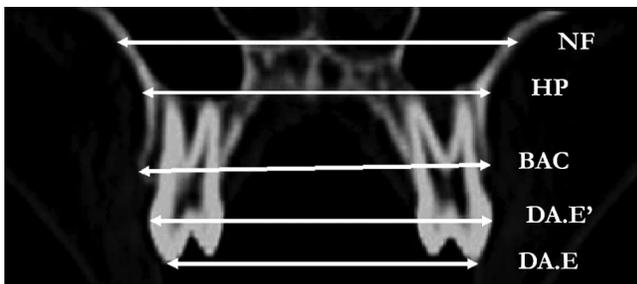


FIGURE 3. External maxillary widths. NF indicates maxillary width parallel to the lower border of the CT image and tangent to the nasal floor at its most superior level; HP, maxillary width parallel to the lower border of the CT image and tangent to the hard palate; BAC, maxillary width at the level of the buccal alveolar crest; DA.E', dental arch external width measured at the most prominent area of the buccal aspect of the posterior teeth; and DA.E, dental arch external width measured at the level of the buccal cusp tips.

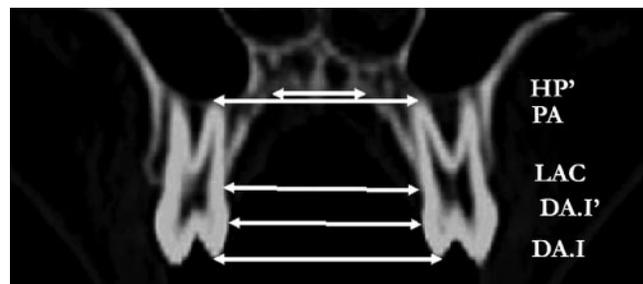


FIGURE 4. Internal maxillary widths. HP' indicates hard palate width; PA, width between the tooth apices measured on the palatal root of the posterior teeth; LAC, maxillary width between the lingual alveolar crests; DA.I', dental arch internal width measured at the most prominent area of the lingual aspect of the posterior teeth; and DA.I, dental arch internal width measured at the level of the palatal cusp tips.

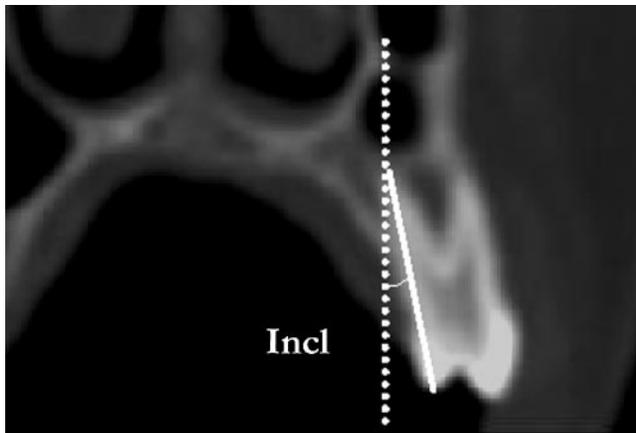


FIGURE 5. Incl—tooth inclination, corresponding to the angle between one line passing through the palatal cusp tip and palatal root apex, and one line perpendicular to the CT image lower border.

the mean of the two measurements. Each tooth category corresponded to the mean of the right and left side teeth. To evaluate the overall effect of maxillary expansion, the two groups were initially pooled together. 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 com-

paring the first and second measurements with Dahlberg's formula¹⁴ and dependent *t*-test, respectively, at a significance level of 5%.

RESULTS

Among all the variables only three had a statistically significant systematic error (NF, HP', and lingual alveolar crest [LAC]), but the mean difference between measurements was not greater than 0.1 mm. The casual errors ranged from 0.16 (DA.E') to 0.51 (Incl).

Maxillary transverse dimensions

The midpalatal suture was successfully opened in all subjects. When the two groups were pooled together, the maxillary transverse dimensions displayed significant increases after RME (Table 1). The transverse increase at the level of the dental arch and alveolar crest were remarkably larger than that observed at the maxillary base.

Both tooth tissue-borne (Table 2) and tooth-borne expanders (Table 3) produced significant increases in maxillary width with decreasing magnitude from the dental arch to the basal area. The maxillary width at the level of the nasal floor (NF) was the only transverse dimension presenting a nonsignificant increase, except for the first premolar area in group II. There were no significant differences between tooth tissue-

TABLE 1. Maxillary Transverse Dimensions Results of the Comparison Between the Pre- and Postexpansion Stages of the Pooled Groups (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change			
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>P</i>
Maxillary first molar area								
NF	68.2	8.1	70.6	8.1	2.4	1.7	3.97	.005*
HP	61.5	3.7	64.2	4.0	2.6	0.9	7.97	.000*
BAC	53.0	1.6	58.7	1.5	5.7	0.8	17.88	.000*
DA.E	48.7	1.3	56.8	1.6	8.1	1.6	14.30	.000*
DA.E'	52.1	1.3	60.2	1.7	8.1	0.7	31.40	.000*
HP'	20.4	2.5	23.2	2.5	2.7	0.4	19.07	.000*
PA	28.7	3.2	34.8	3.8	6.1	1.2	11.95	.000*
LAC	29.2	1.7	34.4	2.4	5.1	1.3	11.10	.000*
DA.I	35.8	1.5	43.1	1.5	7.3	0.6	30.87	.000*
DA.I'	29.2	1.7	35.8	1.7	6.6	0.7	24.55	.000*
Maxillary first premolar area								
NF	38.5	5.9	41.1	6.1	2.5	1.8	3.85	.006*
HP	37.9	3.3	42.5	4.2	4.5	1.4	8.35	.000*
BAC	42.5	2.4	48.5	2.7	6.0	0.9	15.12	.000*
DA.E	37.4	2.1	44.7	2.2	7.2	0.7	26.64	.000*
DA.E'	41.3	1.8	49.0	2.1	7.6	0.5	34.66	.000*
HP'	13.1	1.6	16.5	1.8	3.3	1.0	8.75	.000*
PA	26.8	2.6	32.9	3.1	6.0	1.0	14.52	.000*
LAC	22.6	2.3	28.3	2.2	5.6	1.1	14.3	.000*
DA.I	26.2	2.4	33.5	2.1	7.3	0.6	26.22	.000*
DA.I'	22.4	2.4	28.7	2.3	6.2	0.4	37.74	.000*

* Statistically significant.

TABLE 2. Maxillary Transverse Dimensions Results of the Comparison Between the Pre- and Postexpansion Stages of Haas-type Appliance Group (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change			
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>P</i>
Maxillary first molar area								
NF	64.5	3.7	66.6	3.4	2.1	1.9	2.00	.114
HP	59.6	3.2	62.3	4.2	2.6	1.1	3.84	.018*
BAC	53.2	2.0	58.7	2.5	5.5	0.5	9.16	.002*
DA.E	48.7	1.4	55.9	1.5	7.2	0.7	11.45	.000*
DA.E'	51.7	1.8	59.8	2.4	8.1	0.6	14.73	.000*
HP'	20.0	2.1	22.9	1.9	2.8	0.3	11.57	.000*
PA	27.9	3.4	33.4	4.7	5.4	1.4	4.45	.021*
LAC	28.7	2.3	34.6	3.6	5.9	1.5	5.75	.004*
DA.I	36.1	1.9	43.5	1.7	7.4	0.9	10.27	.000*
DA.I'	28.8	2.2	35.3	2.2	6.5	1.0	8.22	.001*
Maxillary first premolar area								
NF	41.7	7.4	43.5	8.4	1.8	2.1	1.58	.188
HP	39.3	3.9	43.7	5.6	4.3	1.8	3.95	.016*
BAC	42.7	3.5	48.5	4.3	5.8	0.9	6.04	.009*
DA.E	36.3	2.3	43.7	2.1	7.4	0.2	16.82	.000*
DA.E'	40.9	3.0	48.3	3.4	7.4	0.4	11.72	.001*
HP'	13.1	2.1	15.8	2.5	2.6	0.9	4.66	.009*
PA	25.9	1.4	31.3	1.9	5.4	1.0	5.60	.011*
LAC	22.0	3.2	28.6	3.2	6.6	0.6	11.73	.000*
DA.I	25.3	2.9	33.0	2.4	7.7	0.6	9.50	.002*
DA.I'	22.1	3.2	28.5	3.1	6.3	0.5	14.32	.000*

* Statistically significant.

TABLE 3. Maxillary Transverse Dimensions Results of the Comparison Between the Pre- and Postexpansion Stages of Hyrax Group (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change			
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>P</i>
Maxillary first molar area								
NF	71.9	10.1	74.6	10.0	2.6	1.7	3.15	.051
HP	63.5	3.5	66.2	3.1	2.7	0.9	5.97	.009*
BAC	52.9	1.4	58.8	0.6	5.9	1.0	10.91	.001*
DA.E	48.7	1.5	57.7	1.3	8.9	1.8	9.70	.002*
DA.E'	52.4	0.1	60.6	0.7	8.2	0.9	17.62	.000*
HP'	20.8	3.1	23.5	3.3	2.7	0.5	9.52	.002*
PA	29.4	3.5	36.3	2.9	6.8	0.8	14.36	.004*
LAC	29.8	0.8	34.2	0.9	4.3	0.1	66.75	.000*
DA.I	35.6	1.4	42.7	1.6	7.1	0.3	37.40	.000*
DA.I'	29.7	1.1	36.4	0.9	6.7	0.4	31.59	.000*
Maxillary first premolar area								
NF	35.4	0.7	38.7	1.4	3.2	1.4	4.50	.020*
HP	36.0	0.8	40.9	1.2	4.8	1.0	7.59	.016*
BAC	42.0	1.5	48.4	0.4	6.1	1.1	9.14	.011*
DA.E	38.3	1.6	45.5	2.1	7.1	0.9	14.64	.000*
DA.E'	41.7	0.5	49.5	0.7	7.8	0.6	22.85	.000*
HP'	13.2	1.1	17.2	0.4	3.9	0.8	9.27	.002*
PA	27.8	3.5	34.5	3.6	6.7	0.5	20.07	.002*
LAC	23.2	1.0	28.0	0.9	4.7	0.2	33.22	.000*
DA.I	27.1	1.8	34.1	2.2	6.9	0.5	23.72	.001*
DA.I'	22.7	1.2	28.9	1.2	6.2	0.4	24.07	.001*

* Statistically significant.

TABLE 4. Results of the Comparison (*t*-Test) Between the Changes in Maxillary Transverse Dimensions With RME in Groups I (Haas-type Expander) and II (Hyrax)

Variables	Group I				Group II				<i>t</i>	<i>P</i>
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Maxillary first molar area										
NF	2.1	1.9	-0.2	3.8	2.6	1.7	0.9	5.0	0.39	.707
HP	2.6	1.1	1.7	4.2	2.7	0.9	2.1	4.0	0.06	.947
BAC	5.5	0.5	5.0	6.0	5.9	1.0	4.9	7.4	0.57	.592
DA.E	7.2	0.7	6.2	8.0	8.9	1.8	7.4	11.6	1.74	.131
DA.E'	8.1	0.6	7.3	8.7	8.2	0.9	7.1	9.3	0.15	.880
HP'	2.8	0.3	2.5	3.1	2.7	0.5	1.9	3.2	-0.46	.656
PA	5.4	1.4	4.3	7.0	6.8	0.8	6.2	7.7	1.42	.228
LAC	5.9	1.5	3.9	7.2	4.3	0.1	4.2	4.5	-2.02	.089
DA.I	7.4	0.9	6.7	8.7	7.1	0.3	6.7	7.6	-0.60	.569
DA.I'	6.5	1.0	5.6	8.0	6.7	0.4	6.3	7.3	0.36	.724
Maxillary first premolar area										
NF	1.8	2.1	-0.6	3.8	3.2	1.4	1.6	5.1	1.09	.315
HP	4.3	1.8	2.5	6.0	4.8	1.0	3.5	5.5	0.37	.726
BAC	5.8	0.9	4.9	6.8	6.1	1.1	4.9	7.2	0.34	.749
DA.E	7.4	0.2	7.2	7.7	7.1	0.9	6.0	8.4	-0.41	.697
DA.E'	7.4	0.4	7.1	8.0	7.8	0.6	7.2	8.5	0.74	.489
HP'	2.6	0.9	1.8	3.8	3.9	0.8	3.1	4.9	2.10	.079
PA	5.4	1.0	4.4	6.4	6.7	0.5	6.1	7.2	1.94	.123
LAC	6.6	0.6	5.6	7.1	4.7	0.2	4.4	5.0	-5.18	.002*
DA.I	7.7	0.6	7.1	8.4	6.9	0.5	6.4	7.4	-1.58	.187
DA.I'	6.3	0.5	5.9	7.0	6.2	0.4	5.8	6.7	-0.12	.905

* Statistically significant.

TABLE 5. Maxillary Posterior Teeth Inclination Results of the Comparison Between the Pre- and Postexpansion Stages of the Pooled Groups (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change		<i>t</i>	<i>P</i>
	Mean	SD	Mean	SD	Mean	SD		
Incl-P1	-0.2	6.4	2.0	6.9	2.3	2.6	3.49	.003*
Incl-P2	-5.1	5.4	1.5	6.8	6.7	7.4	3.63	.002*
Incl-M1	9.2	5.4	11.7	5.8	2.5	2.8	3.55	.003*

* Statistically significant.

borne and tooth-borne expanders for most maxillary transverse increases (Table 4).

Maxillary posterior teeth inclination

RME led to a buccal tipping of the posterior teeth (Table 5), especially of the second premolars (P2) when compared with the banded teeth, namely the first premolar (P2) and the first molar (M1).

In group I, the tooth tissue-borne expander, showed significant buccal tipping of all posterior teeth (Table 6). On the other hand, group II (Table 7) did not demonstrate any significant change in the inclination of the anchorage teeth but only in the inclination of the second premolars. Intergroup comparison revealed a statistically significant difference only for the first premolars, which presented more buccal tipping in the tooth tissue-borne expander group (Table 8).

DISCUSSION

Use of a small sample in this study was necessary because of ethical concerns. The ethics committee does not allow extending radiation exposure to large human groups for research purposes. In fact, the CT images are not part of routine orthodontic records, and the committee only approved the project because CT scanning can provide RME information not obtainable from other sources, including the periodontal findings that will be reported later.

To overcome the small study sample, patient age and sex were homogenized and all subjects were carefully treated and controlled by the same professional, performing exactly the same amount of expansion in the whole sample. Besides, the high precision of the CT images¹⁵ contributes to the reliability of the outcome and makes the use of a small sample size

TABLE 6. Maxillary Posterior Teeth Inclination Results of the Comparison Between the Pre- and Postexpansion Stages of Haas-type Appliance Group (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change			
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>P</i>
Incl-P1	1.9	3.1	5.6	2.5	3.6	1.1	5.43	.001*
Incl-P2	-1.7	2.6	5.8	5.3	7.5	7.8	2.48	.042*
Incl-M1	10.6	1.0	14.1	1.3	3.5	1.1	7.90	.000*

* Statistically significant.

TABLE 7. Maxillary Posterior Teeth Inclination Results of the Comparison Between the Pre- and Postexpansion Stages of Hyrax Group (Paired *t*-Test)

Variables	Preexpansion		Postexpansion		Change			
	Mean	SD	Mean	SD	Mean	SD	<i>t</i>	<i>P</i>
Incl-P1	-2.5	7.0	-1.6	6.7	0.9	1.2	0.99	.353
Incl-P2	-8.6	3.4	-2.7	2.0	5.9	2.0	2.57	.037*
Incl-M1	7.8	6.1	9.4	6.2	1.6	3.2	1.20	.268

* Statistically significant.

TABLE 8. Results of the Comparison (*t*-Test) Between the Changes in Maxillary Posterior Teeth Inclination With RME in Groups I (Haas-type Expander) and II (Hyrax)

Variables	Group I				Group II				<i>t</i>	<i>P</i>
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Incl-P1	3.6	1.1	0.7	6.0	0.9	1.2	-1.7	6.0	-2.43	.029*
Incl-P2	7.5	7.8	-3.8	17.9	5.9	2.0	-6.6	16.4	-0.41	.683
Incl-M1	3.5	1.1	1.5	5.0	1.6	3.2	-3.5	7.8	-1.37	.190

* Statistically significant.

possible. The problem of a small study sample is related to the power of the *t*-test to reveal statistically significant differences, which is then reduced. When significant differences are demonstrated in such situations, they clearly exist and are likely of clinical importance. However, the absence of significant differences does not necessarily indicate that they do not exist.¹⁶

The reformatted CT coronal images were used for assessment of the orthopedic and orthodontic effects of RME at the first premolar and permanent first molar areas. These data, which formerly could only be obtained with the surgical placement of metallic implants,¹⁷⁻²⁰ allowed comparison between the tooth tissue-borne expander and tooth-borne expander to investigate assumptions reported in the literature.⁹⁻¹¹ The largest magnitude of suture splitting with the smallest buccal movement of the posterior teeth would reveal the most effective appliance.

RME was very effective in increasing maxillary transverse dimensions in all measured areas (Table 1). The decreasing upward expanding effect^{4,5,7,18-23} was confirmed with CT. The dental arch displayed larger increases in width, which were close to the amount of screw activation (7 mm). The dental arch

external width (DA.E), measured at the level of the buccal cusp tips, was slightly larger than the screw expansion, probably due to the combined effects of expansion and tooth inclination.

The smallest maxillary transverse increases were found at the level of the NF. At this area, the orthopedic effect was on-third of the expanding screw opening, on average, even though some individuals displayed expansion larger than 50% of the amount of activation. Changes in maxillary width at the level of the hard palate (HP and HP') and in the alveolar crests (BAC and LAC) were of intermediate magnitude. This differential effect of RME is explained by the lateral rotation of the maxillary halves, with a fulcrum located close to the frontomaxillary suture, in addition to the orthodontic effect, represented by the buccal movement of the posterior teeth.^{1,5,6,17-24}

These findings are in agreement with studies conducted on frontal cephalograms^{4,5,7,21-23} and with the use of implants.¹⁷⁻²⁰ Despite the heterogeneous sample regarding age, sex, and amount of expansion, Krebs¹⁹ observed quite similar outcomes, with a mean increase in intermolar distance three times larger than maxillary expansion at the zygomatic process level. Wertz and Dreskin²³ observed 2.5 mm of maxillary

base widening compared with a 6.5 mm increase in intermolar distance.

The effectiveness of tooth tissue-borne and tooth-borne expanders has been compared using the ratio between orthopedic and orthodontic effects elicited by the two types of expanders.^{4,5,9,11} The evaluation of groups I and II shows that both expanders produced a significant increase in maxillary transverse dimensions (Tables 2 and 3) but the amount of increase decreased from the dental arch to the basal areas.

Increases in maxillary width at the level of the NF did not display any statistical significant increase in either group except at the first molar area in group II, the tooth-borne expander. Lateral rotation of the maxillary halves may have lowered the NF^{8,11,24} and, therefore, the reference point for NF. Thus, the second measurement could have been conducted at a lower level, at a narrower maxillary area, which may underestimate the real transverse increase in some instances. The restricted study sample also contributed to such outcomes because evaluation of the pooled groups showed that the increase in NF was statistically significant at the areas of first premolars and molars (Table 1).

Width changes in almost all variables were not statistically different between groups I and II (Table 4). The exception was the premolar LAC width, which had a larger increase in the tooth tissue-borne expander group, probably due to the compression of the acrylic pad close to this area.

During the past 30 years, it has been stated that only expanders with an acrylic pad might optimize the orthopedic effect of RME and preserve maxillary base expansion during the retention stage, avoiding the "bone movement through the teeth."⁹⁻¹¹ Considering these outcomes, that statement⁹⁻¹¹ was not confirmed. The observation of similar changes in both study groups after the retention stage of RME does not allow assignment of such importance to the acrylic pad for establishment and maintenance of midpalatal suture opening. The tooth-borne expanders, similar to the tooth tissue-borne expanders, provided a significant maxillary expansion. PA cephalometric studies^{4,5} and investigation on dental casts³ corroborate these findings.

The RME procedure elicited a statistically significant buccal inclination of the posterior teeth (Table 5). However, the magnitude of second premolars increased inclination of 6.7° (SD 7.4°) was larger than that displayed by the appliance supporting first premolars and molars, which presented inclination increases of 2.3° (SD 2.6°) and 2.5° (SD 2.8°), respectively.

These differences in inclination may be related to the means of delivery of the expanding force. The second premolars are expanded by the lingual bar con-

necting the first premolar and the first molar on the lingual aspect. This simple force applied to the crown, far from the center of resistance, might generate a buccal moment and, therefore, led to some increased buccal inclination.²⁵ On the other hand, the supporting teeth were expanded by bands firmly attached to the appliance. As the screw was activated, the bands provided resistance to inclination, therefore, leading to greater bodily buccal movement of the supporting teeth. Such an explanation may be demonstrated by the changes in width between the tooth apices (PA) presented in Table 1. At the area of the supporting teeth, the six mm increase in this dimension was almost equal to the amount of screw opening.

Individual assessment of groups I and II presented similar outcomes to those above described (Tables 6 and 7). Intergroup comparison demonstrated a significant difference only for the first premolars, which displayed a larger inclination in group I, the tooth tissue-borne expander (Table 8). The mean changes in second premolars inclination and first molars inclination in that group were also greater but not significantly greater than those observed for group II.

The mild differences between the tooth tissue-borne and the tooth-borne expanders may reflect the different force delivery systems of both types of appliances. In a study on the biomechanics of RME, Braun et al²⁶ stated that the sutural expansion designs that use an acrylic interface with the teeth were far less stiff than those constructed solely of soldered stainless steel wire. Those types of expansion devices allowed for a greater degree of undesirable maxillary tipping in the frontal plane during midpalatal suture expansion. The buccal inclination observed after RME is not only a consequence of tooth movement within the alveolar bone but also a resultant from lateral rotation of the maxillary halves.⁶ Therefore, the larger buccal inclination of the posterior teeth observed in group I seems logical.

Although most of the current results supported previous cephalometric and dental cast investigations,³⁻⁵ future studies, with similar methodology, but with larger samples should be undertaken to confirm these tendencies.

CONCLUSIONS

- RME produced a significant increase in all measured transverse dimensions, with decreasing magnitude from dental arch to basal bone; the transverse increase at the level of the NF corresponded to one-third to one-half of the amount of screw activation.
- Tooth-borne and tooth tissue-borne expanders tended to produce similar orthopedic effects.
- The expansion led to buccal movement of the max-

illary posterior teeth, by tipping and bodily translation.

- The second premolars displayed more buccal tipping than the supporting teeth.
- The tooth tissue–borne expander produced a greater change in the axial inclination of supporting teeth, especially in the first premolars, compared with the tooth-borne expander.

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