ORIGINAL ARTICLE

Periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders: A computed tomography evaluation

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Introduction: The force delivered during rapid maxillary expansion (RME) produces areas of compression on the periodontal ligament of the supporting teeth. The resulting alveolar bone resorption can lead to unwanted tooth movement in the same direction. The purpose of this study was to evaluate periodontal changes by means of computed tomography after RME with tooth-tissue-borne and tooth-borne expanders. **Methods:** The sample comprised 8 girls, 11 to 14 years old, with Class I or II malocclusions with unilateral or bilateral posterior crossbites Four girls were treated with tooth-tissue-borne Haas-type expanders, and 4 were treated with tooth-borne Hyrax expanders. The appliances were activated up to the full 7-mm capacity of the expansion screw. Spiral CT scans were taken before expansion and after the 3-month retention period when the expander was removed. One-millimeter thick axial sections were exposed parallel to the palatal plane, comprising the dentoalveolar area and the base of the maxilla up to the inferior third of the nasal cavity. Multiplanar reconstruction was used to measure buccal and lingual bone plate thickness and buccal alveolar bone crest level by means of the computerized method. **Results and Conclusions:** RME reduced the buccal bone plate thickness of supporting teeth 0.6 to 0.9 mm and increased the lingual bone plate thickness 0.8 to 1.3 mm. The increase in lingual bone plate thickness of the maxillary posterior teeth was greater in the tooth-borne expansion group than in the tooth-tissue-borne group. RME induced bone dehiscences on the anchorage teeth's buccal aspect (7.1 $\pm$ 4.6 mm at the first premolars and 3.8 $\pm$ 4.4 mm at the mesiobuccal area of the first molars), especially in subjects with thinner buccal bone plates. The tooth-borne expander produced greater reduction of first premolar buccal alveolar bone crest level than did the tooth-tissue-borne expander. (Am J Orthod Dentofacial Orthop 2006;129:749-58)

Along with the desired orthopedic effect of midpalatal suture splitting, rapid maxillary expansion (RME) unavoidably elicits an orthodontic effect of buccal movement of the posterior teeth.[1-16] The force delivered by the expander produces areas of compression on the periodontal ligament of the supporting teeth.[11] Thereafter, alveolar bone resorption leads to tooth movement in the same direction.[11] Tooth-borne expanders, which concentrate the force at the dentoalveolar area, might be more iatrogenic from a periodontal standpoint and might cause more root resorption than tooth-tissue-borne expanders, which distribute the force between the anchorage teeth and the palatal surface.[17] The impact on the buccal bone plate from both types of expander could be extremely important.

Some investigators have shown strong correlations between buccal tooth movement and bone dehiscences in animals.[18-20] However, few researchers have reported on periodontal status after RME,[11,21,22] especially in humans.[21] This might be because conventional radiographs, which comprise most orthodontic records, show 2-dimensional and superimposed images and do not show the thickness and the level of the buccal and lingual bone plates.[23-25]

The need to define the periodontal consequences of RME, which is routinely used in clinical orthodontic

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practice, has led to the use of computed tomography (CT), a precise and useful tool in this kind of investigation. CT diagnostic imaging uses x-rays and allows reproduction of a real maxillary section in any plane, showing all anatomical structures in depth.[26-29] Observation of buccal and lingual bone plate images on CT allows a quantitative evaluation of this area. Therefore, we aimed to analyze, by means of spiral CT, the effect of RME on the periodontal tissue, comparing tooth-tissue-borne and tooth-borne expanders.

MATERIAL AND METHODS

Our study sample (n = 8) was selected from a larger group of 87 young subjects with Angle Class I or Class II malocclusions with unilateral or bilateral posterior crossbites who sought orthodontic treatment at the Department of Orthodontics, Bauru Dental School, University of São Paulo. The exclusion criteria were (1) age below 11 and above 14 years, (2) persistence of any deciduous teeth, (3) absence of maxillary posterior permanent teeth, (4) metallic restorations on maxillary posterior teeth, (5) previous periodontal disease, (6) previous orthodontic treatment, and (7) male sex. This led to a sample of 8 girls, who were randomly divided into 2 groups and paired according to the thickness of the buccal bone plate of the maxillary posterior teeth.

Group 1 comprised 4 girls with a mean age of 12.4 years (11.4-13.6 years). RME was accomplished with a tooth-tissue-borne Haas-type expander before fixed appliance mechanotherapy. The 7-mm screw (Dentaurum, Ispringen, Germany) was activated with a complete turn after placement, followed by quarter turns in the morning and evening[5] up to locking, on the sixteenth day. Thus, the expansion screw was activated exactly 7 mm in all patients. After the active expansion phase, the screw was fixed with acrylic resin, and the appliance was kept as a retainer for 3 months.

Group 2 comprised 4 girls with a mean age of 12.6 years (11.5-13.9 years). RME was accomplished with a Hyrax tooth-borne expander, followed by fixed appliance mechanotherapy. During the active expansion stage, the 7-mm screw (Dentaurum) was activated as described for Group 1.

CT images were taken before expansion and after the 3-month retention period when the expander was removed. For that purpose, 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 1 second per section. A FC 30 scanning filter, field of view of 12.6 x 12.6 cm, and a matrix of 512 x 512 pixels were used. The window width was 2400HU with a center of 1300 Hounsfield unit (HU).

Fig 1. Axial section, parallel to palatal plane, at level of right maxillary first molar furcation.

The machine's perpendicular light beam was used to standardize the head position in all 3 planes and thus allow comparison of the images before and after expansion.[15] Each patient was positioned lying on the table with the Camper's plane perpendicular to the ground, with the longitudinal light beam passing through the center of glabella and filtrum and the transverse light beam passing through the lateral eye canthus. The teeth were kept apart to prevent imaging the mandibular dental arch. One-millimeter thick axial sections were made parallel to the palatal plane, comprising the dentoalveolar and basal areas of the maxilla, up to the lower third of the nasal cavity. The imaged area added up to 36 to 40 mm and thus 36 to 40 sections.

The data were transferred to a network computer workstation (Silicon Graphics, Toshiba Corporation Medical Systems Company) with Alatoview software (Toshiba Corporation Medical Systems Company) on which 2-dimensional reformatted images were generated and measured by the computerized method.

Measurement of alveolar bone thickness of the maxillary posterior teeth at the buccal and lingual aspects was made by an axial section parallel to the palatal plane, at the level of the right maxillary permanent first molar furcation (Fig 1). Figure 2 illustrates the linear variables obtained on the magnified image (4 x) before and after expansion. When tooth rotations were present, the thickness of the bone plate was measured where the root was closer to the external contour of the alveolar ridge.

Evaluation of the buccal alveolar bone crest level of the maxillary posterior teeth was made by means of orthoradially reformatted images perpendicular to the contour of the dental arch, passing through the center of

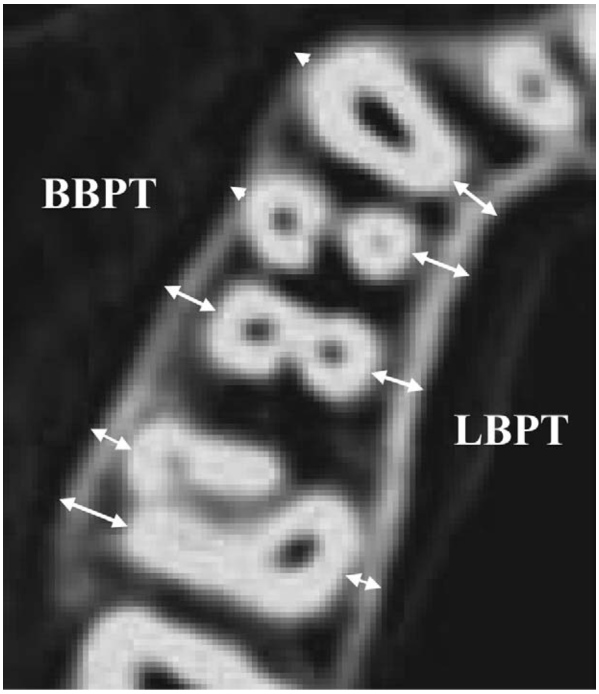

Fig 2. Measurement of maxillary posterior teeth bone plate thickness. BBPT: buccal bone plate thickness measured from external border of buccal cortical plate to center of buccal aspect of dental root of canine, first premolar, and second premolar, and to center of mesial and distobuccal roots of first molar, at both sides. LBPT: lingual bone plate thickness measured from external border of palatal cortical plate to center of palatal aspect of dental root of canine, first premolar, and second premolar, and to center of palatal root of first molar, at both sides.

the buccal aspect of the canines and premolars and through the center, mesial, and distal areas of the buccal aspect of the first molars. Figure 3 illustrates the linear variable obtained on each of these 6 images both before and after expansion.

Statistical analyses

All measurements were made twice with a 1-month interval by the same calibrated examiner (D.G.G.). Statistical analysis was performed by using the mean of the 2 measurements. Each tooth category corresponded to the mean of the right and the left teeth. The mean and standard deviation of each variable were calculated before and after expansion, as well as the changes between these stages. To evaluate the overall effect of maxillary expansion, the 2 groups were initially pooled. Dependent *t* tests were used to compare each variable in the 2 stages in the same group, and independent *t* tests were used to compare the variable changes between groups The Pearson correlation test was used to evaluate the relationship between initial buccal bone plate thickness (BBPT) and buccal alveolar crest level (BACL) changes after RME. Results were regarded as significant for $P < .05$.

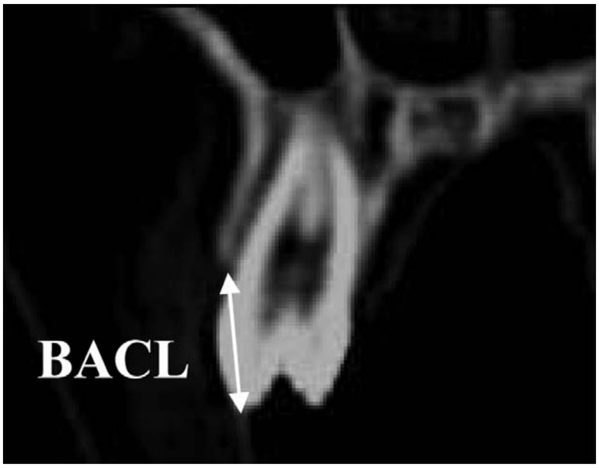

Fig 3. Measurement of maxillary posterior teeth buccal alveolar crest level. BACL: buccal alveolar crest level measured from buccal cusp tip to buccal alveolar crest.

Casual and systematic errors were calculated comparing the first and second measurements with Dahlberg's formula[30] and dependent *t* test, respectively, at a significance level of 5%.

RESULTS

No variable had a statistically significant systematic error. The casual errors ranged from 0.09 to 0.20.

Evaluation of the pooled groups showed that RME reduced the BBPT of the supporting teeth by 0.6 to 0.9 mm (Table I). The Haas-type (Table II) and hyrax (Table III) expanders showed the same results, reducing alveolar bone thickness on the buccal aspect of the banded teeth, whereas the bone plate of adjacent teeth—canines and second premolars—remained almost unchanged. Therefore, there were no significant differences in the BBPT changes between the groups (Table IV).

Opposite the buccal bone plate, the lingual bone plate thickness (LBPT) increased after expansion, especially at the first premolar and molar areas, with a mean of 1.3 ± 0.6 mm and 0.8 ± 0.7 mm, respectively (Table I). Group 2 had similar outcomes (Table III), whereas group 1 had just a significant thickening of the lingual bone plate at the area of the first premolars (Table II). Intergroup comparisons in Table IV indicate that the tooth-borne expander produced greater increases in the LBPT at the second premolar and first

Table I. Pooled groups BBPT and LBPT expansion changes (paired *t* test)

	Preexpansion		*Postexpansion*		*Change*			
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	t	P
BBPT								
Canine	0.7	0.1	0.9	0.1	0.2	0.2	3.38	.004*
1st premolar	0.8	0.4	0.2	0.4	−0.6	0.3	8.34	.000*
2nd premolar	1.7	0.6	1.5	0.5	−0.2	0.5	1.80	.090
1st molar-mesial	1.2	0.5	0.5	0.4	−0.7	0.3	7.74	.000*
1st molar-distal	2.4	0.5	1.5	0.6	−0.9	0.3	9.31	.000*
LBPT								
Canine	2.5	1.0	2.7	1.2	0.2	0.6	1.04	.311
1st premolar	2.4	0.7	3.7	1.0	1.3	0.6	8.04	.000*
2nd premolar	2.6	0.5	3.0	0.9	0.4	0.5	2.32	.034*
1st molar	1.8	0.4	2.6	0.7	0.8	0.7	4.58	.000*

*Statistically significant.

Table II. Group 1 (Haas-type appliance) BBPT and LBPT expansion changes (paired *t* test)

	Preexpansion		*Postexpansion*		*Change*			
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	t	P
BBPT								
Canine	0.7	0.1	0.9	0.1	0.2	0.2	1.99	.085
1st premolar	0.8	0.5	0.3	0.4	−0.5	0.3	4.01	.005*
2nd premolar	1.7	0.5	1.6	0.5	−0.1	0.2	0.93	.380
1st molar-mesial	1.1	0.6	0.5	0.5	−0.6	0.4	3.82	.006*
1st molar-distal	2.5	0.5	1.5	0.5	−1.0	0.3	7.24	.000*
LBPT								
Canine	2.7	1.3	2.8	1.5	0.1	0.8	0.49	.638
1st premolar	2.2	0.8	3.2	1.1	1.0	0.7	4.25	.004*
2nd premolar	2.8	0.5	2.7	0.9	−0.1	0.5	0.24	.813
1st molar	1.9	0.5	2.2	0.7	0.3	0.5	1.32	.228

*Statistically significant.

Table III. Group 2 (hyrax) BBPT and LBPT expansion changes (paired *t* test)

	Preexpansion		*Postexpansion*		*Change*			
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	t	P
BBPT								
Canine	0.6	0.1	0.8	0.1	0.2	0.2	2.69	.030*
1st premolar	0.8	0.3	0.1	0.3	−0.7	0.1	10.95	.000*
2nd premolar	1.8	0.8	1.4	0.5	−0.4	0.7	1.61	.150
1st molar-mesial	1.3	0.4	0.5	0.5	−0.8	0.2	10.02	.000*
1st molar-distal	2.3	0.5	1.5	0.6	−0.8	0.3	5.81	.001*
LBPT								
Canine	2.3	0.7	2.5	0.8	0.2	0.4	1.24	.251
1st premolar	2.6	0.5	4.1	0.8	1.5	0.5	8.22	.000*
2nd premolar	2.5	0.5	3.2	0.8	0.7	0.3	5.54	.001*
1st molar	1.7	0.4	3.1	0.3	1.4	0.2	15.49	.000*

*Statistically significant.

molar areas compared with the tooth-tissue-borne expander.

Table V shows that RME caused a significant reduction of alveolar crest level on the buccal aspect of the supporting teeth, shown by the increase in the BACL variable of the first premolars and molars. Among the banded teeth, the first premolars had the largest bone dehiscences, with a mean of 7.1 ± 4. 6mm.

Table IV. Intergroup comparison of BBPT and LBPT expansion changes (*t* test)

	Group 1 Haas-type appliance				*Group 2 Hyrax*					
Variable	*Mean*	*SD*	*Minimum*	*Maximum*	*Mean*	*SD*	*Minimum*	*Maximum*	t	P
BBPT										
Canine	0.2	0.2	−0.1	0.5	0.2	0.2	0	0.6	0.26	.792
1st premolar	−0.5	0.3	−0.9	0	−0.7	0.1	−1.1	−0.5	−1.65	.119
2nd premolar	−0.1	0.2	−0.4	0.3	−0.4	0.7	−2.1	0.1	−1.20	.249
1st molar-mesial	−0.6	0.4	−1.4	0.2	−0.8	0.2	−1.3	−0.7	−1.27	.222
1st molar-distal	−1.0	0.3	−1.7	−0.6	−0.8	0.3	−1.2	−0.2	0.81	.429
LBPT										
Canine	0.1	0.8	−1.0	1.1	0.2	0.4	−0.2	0.9	0.13	.891
1st premolar	1.0	0.7	−0.1	1.9	1.5	0.5	1.0	2.5	1.47	.162
2nd premolar	−0.1	0.5	−0.6	0.7	0.7	0.3	0.2	1.3	3.45	.003*
1st molar	0.3	0.5	−0.6	0.9	1.4	0.2	1.2	1.7	5.34	.000*

*Statistically significant.

Table V. Pooled groups BACL expansion changes (paired *t* test)

	Preexpansion		*Postexpansion*		*Change*			
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	t	P
Canine	12.2	1.0	12.0	0.9	−0.2	0.7	0.89	.387
1st premolar	9.9	0.7	17.0	4.3	7.1	4.6	6.05	.000*
2nd premolar	8.6	0.9	8.8	0.8	0.2	0.2	1.18	.255
Mesial 1st molar	8.6	0.7	12.4	4.7	3.8	4.4	3.26	.005*
Middle 1st molar	8.0	0.8	8.6	0.8	0.6	0.6	3.62	.002*
Distal 1st molar	8.2	0.7	8.5	0.7	0.3	0.3	3.00	.010*

*Statistically significant.

Of the 3 areas investigated on the buccal aspect of the first molars, the mesial aspect demonstrated the greatest bone resorption, corresponding to 3.8 ± 4.4 mm.

Group 1 had a statistically significant increase in the BACL only in the first premolar area (Table VI). Group 2 had a significant increase in the BACL on the first premolar and on the first molar mesial, central, and distal areas (Table VII). Intergroup comparison of the changes in these areas indicated that the tooth-borne expander produced significantly larger bone dehiscences than did the tooth-tissue-borne expander only at the first premolar area (Table VIII).

The Pearson correlation test showed a negative statistically significant correlation (r = −0.733; *P* = .039) between the thickness of the buccal alveolar crest at treatment onset and the alveolar crest level changes after expansion.

DISCUSSION

The use of a small sample in this study was justified by ethical considerations, which limit radiation exposure for research purposes. CT images are not part of routine orthodontic records, and the ethics committee approved the project only because CT scanning can provide RME information not obtainable from other methods, mainly the periodontal findings. To overcome the small study sample, patient age and sex were homogenized, and all subjects were carefully treated and controlled by the same professional, who performed exactly the same amount of expansion in each patient. The high precision of quantitative analyses on CT images contributes to the reliability of the outcomes and makes the small sample size acceptable.[31] The problem of a small study sample is related to the power of the *t* test, which is then reduced, to show statistically significant differences. When significant differences are demonstrated in such a situation, they really exist. However, the absence of significant differences does not necessarily indicate that they do not exist.[32]

The orthodontic effect of RME, represented by posterior tooth buccal movement and demonstrated in a previous study,[15] led to a reduction in the BBPT (Table I). This thinning was statistically significant only for the first premolars and molars—ie, the teeth that supported the bands and showed buccal translation movement.[15] A histological investigation in monkeys had

Table VI. Group 1 (Haas-type appliance) BACL expansion changes (paired *t* test)

Variable	Preexpansion Mean	Preexpansion SD	Postexpansion Mean	Postexpansion SD	Change Mean	Change SD	t	P
Canine	12.7	1.3	12.5	1.1	−0.2	0.8	0.66	.524
1st premolar	10.4	0.4	15.0	4.6	4.5	4.6	2.73	.029*
2nd premolar	9.3	0.4	9.3	0.6	0.0	0.4	0.03	.969
Mesial 1st molar	9.0	0.8	12.1	4.9	3.1	4.6	1.87	.102
Middle 1st molar	8.3	1.1	8.8	0.9	0.5	0.6	2.17	.066
Distal 1st molar	8.7	0.6	8.8	0.4	0.1	0.2	1.58	.173

*Statistically significant.

Table VII. Group 2 (hyrax) BACL expansion changes (paired *t* test)

Variables	Preexpansion Mean	Preexpansion SD	Postexpansion Mean	Postexpansion SD	Change Mean	Change SD	t	P
Canine	11.8	0.5	11.6	0.4	−0.2	0.7	0.54	.603
1st premolar	9.5	0.6	19.1	2.8	9.6	3.1	8.62	.000*
2nd premolar	8.0	0.7	8.2	0.7	0.2	0.4	1.71	.130
Mesial 1st molar	8.1	0.3	12.7	4.8	4.6	4.9	2.62	.034*
Middle 1st molar	7.6	0.4	8.3	0.7	0.6	0.6	2.82	.025*
Distal 1st molar	7.9	0.7	8.2	0.7	0.3	0.3	2.49	.041*

*Statistically significant.

Table VIII. Intergroup comparison of BACL expansion changes (*t* test)

Variable	Group 1 Haas-type appliance Mean	SD	Minimum	Maximum	Group 2 Hyrax Mean	SD	Minimum	Maximum	t	P
Canine	−0.2	0.8	−1.2	0.9	−0.2	0.7	−1.6	0.4	0.12	.900
1st premolar	4.5	4.6	0	10.5	9.6	3.1	3.9	13.8	2.56	.022*
2nd premolar	0.0	0.4	−0.6	0.9	0.2	0.4	−0.3	1.1	1.13	.274
Mesial 1st molar	3.1	4.6	0.2	10.9	4.6	4.9	0.1	11.1	0.61	.545
Middle 1st molar	0.5	0.6	−0.4	1.6	0.6	0.6	−0.2	1.8	0.42	.677
Distal 1st molar	0.1	0.2	−0.2	0.6	0.3	0.3	−0.2	0.8	1.10	.288

*Statistically significant.

already demonstrated resorption of the buccal alveolar bone throughout the roots of the supporting teeth 2 weeks after the onset of RME.[11] Such reductions in BBPT indicate the absence of correspondent compensatory bone apposition under the buccal periosteum, at least during the 4-month period from the onset of activation up to removal of the expander. Sarikaya et al[33] observed a similar fact, but on the lingual bone plate of maxillary and mandibular incisors receiving retraction with edgewise appliances, after extraction of 4 premolars.

Both the tooth-tissue-borne (Table II) and the tooth-borne (Table III) expanders showed similar behaviors regarding the BBPT. Both appliances reduced the BBPT of the supporting teeth, whereas the bone plate on the canines and second premolars remained almost unchanged. Despite the apparent tendency of the tooth-borne appliance to elicit a larger reduction in the BBPT dimension, comparison between groups did not indicate statistically significant differences (Table IV).

Opposite the buccal aspect, the LBPT increased at the anchorage teeth (Table I). These changes are related to the RME's orthodontic effect. After lingual movement of the permanent incisors, Sarikaya et al[33] and Wehrbein et al[34] observed compensatory resorption under the periosteum on the buccal bone plate, which kept its thickness constant. Our findings do not corroborate these outcomes, perhaps because of the shorter follow-up period.

The tooth-borne expander produced significant increases in LBPT in all supporting teeth (Table III). On

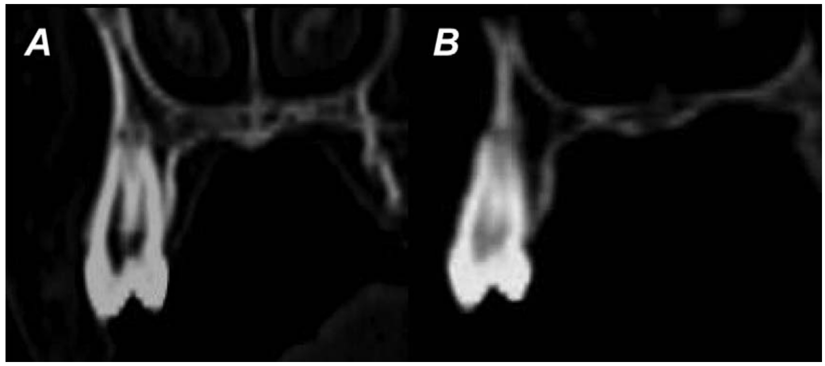

Fig 4. A, Pretreatment and **B,** postexpansion right first premolar orthoradially reformatted images of group 2 patient. Note bone dehiscence.

the other hand, the tooth-tissue-borne expander led to a significant increase only in first premolars' LBPT (Table II). Intergroup comparison indicated that the hyrax expander leads to a larger increase of LBPT during expansion, especially at the second premolar and first molar areas (Table IV). These outcomes suggest that the pressure exerted by the Haas expander's acrylic pad seems to stimulate some bone resorption at the palatal aspect of the alveolar process.[35-37]

After RME, bone dehiscences appeared on the buccal aspect of the supporting teeth, as shown by the increase in the BACL dimension (Table V). The first premolars had the greatest resorptions of the buccal alveolar crest (Fig 4). The mesiobuccal area of the first molars, which was more prominent and therefore initially covered by a thinner bone plate in the subjects (Table I), exhibited more changes than the central and distobuccal areas. The second premolars, which were not banded, and the canines, which were not surrounded by the expander, did not show reductions in the alveolar crest level.

Many studies have addressed the relationship between orthodontics and periodontics, focusing on the effects of tooth movement on the intact or reduced periodontium. However, the effects of RME on human alveolar bone have never been reported in the literature, probably due to methodological difficulties. Greenbaum and Zachrisson,[21] Northway and Meade,[37] Vanarsdall,[38] and Watson[39] suggested only that RME could cause bone dehiscences based on clinical observation of attachment loss and gingival recession on the buccal aspect of maxillary posterior teeth in a number of patients some time after expansion.

There is a clear correlation between buccal tooth movement and bone dehiscences. Engelking and Zachrisson,[40] Steiner et al,[18] Thilander et al,[19] and Wennström et al,[20] in animal investigations, demonstrated that buccal tooth movement with mild forces increases the distance between the cementoenamel junction and the buccal alveolar crest. Wehrbein et al[25] presented similar conclusions in a cadaver study. Andlin-Sobocki and Bondin,[41] Andlin-Sobocki and Persson,[42] Årtun and Grobéty,[43] and Årtun and Krogstad[44] observed gingival recession in teeth submitted to natural or orthodontic buccal movement.

According to Melsen,[45] buccolingual tooth movement can occur concurrently with or through the alveolar bone. The first situation occurs only with direct or frontal bone resorption. In this case, there would be resorption of the bone surface at the periodontal ligament pressure area, with compensatory bone apposition at the external surface of the alveolar process. However, when the force magnitude induces indirect bone resorption, the clasts resorb the bone plate of the external surface in the direction of the periodontal ligament, therefore leading to tooth movement through the thin alveolar bone plate. In some patients, RME induced orthodontic movement of the first premolars and first molars, with transposition of the alveolar bone. The intense force delivered on the supporting teeth during activation of the screw[46,47] leads to hyalinization of the periodontal ligament on the pressure side.[11,22,48] Initially, tissue necrosis would be positive, since it would obstruct alveolar bone resorption and consequent orthodontic tooth movement. Unable to move, the teeth become ideal supporting units for maxillary orthopedic movement. Therefore, at the onset of expansion, the accumulated force is used to promote maxillary splitting. Probably afterwards, with the permanence of residual forces left because the orthopedic effect is smaller than the amount of expansion, the orthodontic effect occurs. The negative consequences of periodontal ligament hyalinization can then appear,

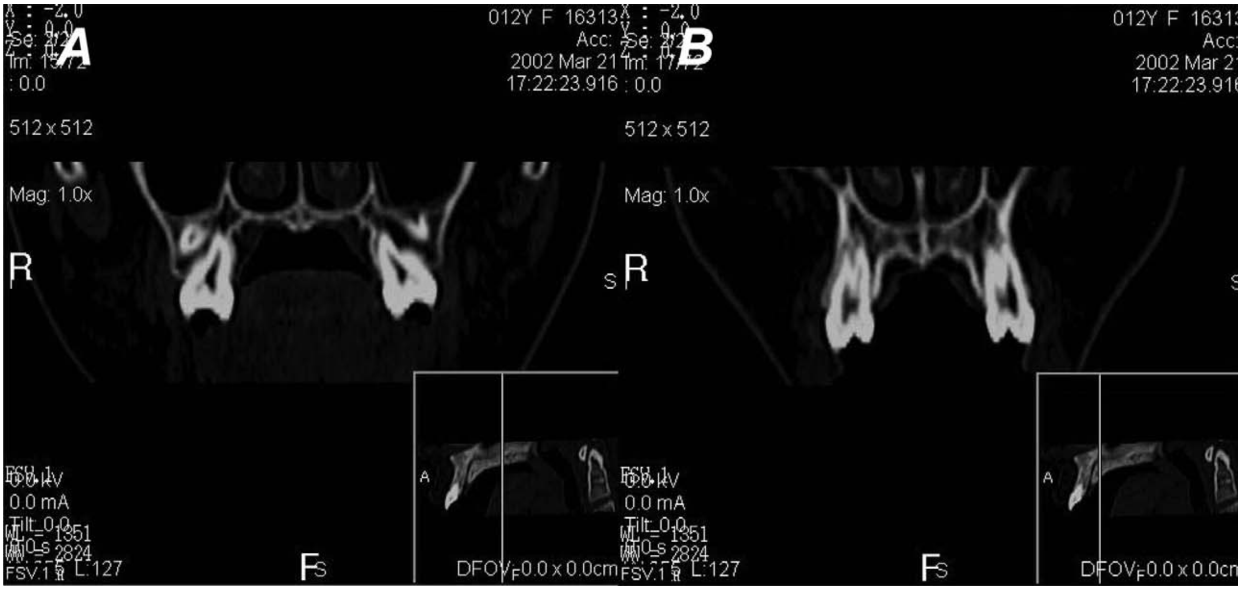

Fig 5. Maxillary external contour on CT coronal reconstruction: **A,** First molar area; **B,** first premolar area.

represented by the supporting teeth's buccal bone plate and buccal root resorption.[17,22,49,50]

The first premolars had a larger reduction in the BACL when compared with the first molars, even though they were submitted to similar forces. In addition to the small difference in BBPT (Table I), the great difference between these teeth is the anatomical area in which they are located. The first molars are located at a maxillary region that widens upwards (Fig 5, *A*). On the other hand, the first premolars are located in an area that becomes narrower upwards (Fig 5, *B*). In this area, when there is bodily buccal movement, the root can perforate the alveolar bone much more easily.

The periodontal effects in both groups were similar to those described above for RME (Tables VI and VII). The tooth-borne expander produced more bone dehiscences on the buccal aspect of the supporting teeth than did the tooth-tissue-borne expanders. However, these differences between groups were statistically significant only in the first premolar area (Table VIII). The tooth-borne expander undoubtedly concentrates more force on the supporting teeth. Haas[48] defined the tooth-tissue-borne expander as an appliance with maximum anchorage, because it has 3 areas of force distribution—the palate, the periodontal ligament fibers, and the buccal bone plate. He regarded the tooth-borne expander as having deficient anchorage because of force transmission only to the periodontium. Agreeing with this assumption, Odenrick et al[17] found that the hyrax expander elicits more root resorption on the first premolars' buccal aspect than does the Haas expander. Our findings demonstrated that the acrylic pad did not prevent but decreased the BACL changes.

Analysis of the minimum and maximum BACL variable changes in Table VIII shows that the outcomes had large individual variations. Even though the first premolars' BACL mean increase in group 1 was 4.5 mm, alveolar crest resorption range was 0 to 10.5 mm. In group 2, the mean change of the same variable was equal to 9.6 mm, yet ranged from 3.9 to 13.8 mm. The same was observed at first molars' mesiobuccal area. The girls with thinner buccal bone plates had larger reductions of alveolar crest level after expansion, regardless of the appliance. There was a negative statistically significant correlation between the thickness of the buccal alveolar crest at treatment onset and the alveolar crest level changes after expansion ($r = -0.733$; $P = .039$). In patients with initially thicker bone plates, RME did not have such negative effects on the buccal periodontium.

Even though RME might trigger bone dehiscences on the buccal aspect of the supporting teeth, especially in patients with thin bone plates, the clinical periodontal status did not indicate such change. No gingival recessions were observed immediately after expansion. Migration of junctional epithelium and loss of connective attachment do not follow the apical displacement of the buccal alveolar crest[18-20] especially in the absence of inflammation.[20] However, what will be the periodontal status in the long-term? Greenbaum and

Zachrisson[21] conducted a clinical comparison of the periodontal status of young subjects receiving orthodontic treatment with RME, with slow expansion and without mechanics for expansion (control). Three years after fixed appliance removal, good periodontal conditions were observed in both groups. On average, the groups that received expansion had minimal differences in relation to the control group. However, the individual variations were remarkable. Most patients with attachment loss at the maxillary first molar buccal aspect were in the RME group. Vanarsdall[38] reported the outcomes of a longitudinal periodontal evaluation in young patients receiving orthodontic treatment with and without RME. In the first group, 20% of the patients had gingival recession 8 to 10 years after expansion, compared with 6% in the group treated only with edgewise appliances.

The main factors predisposing to gingival recession are buccally positioned or moved teeth, bone dehiscences, and thin and friable keratinized mucosa.[41-44,51,52] However, recessions are triggered only by mechanical brushing trauma or plaque-induced inflammation.[52] Therefore, the quality of the keratinized mucosa and especially the toothbrushing technique should be strictly controlled in patients who receive RME. Without precipitating factors, even a long connective attachment does not affect the supporting teeth's soft-tissue periodontium.

On the other hand, evidence has demonstrated that lingual tooth movement leads to bone apposition on the buccal alveolar crest in the coronal direction.[19,40] Overcorrection of the maxillary dental arch constriction during expansion allows future uprighting of the posterior teeth with fixed appliances. It would be interesting to intensify transverse overcorrection to favor bone regeneration after expansion. In addition, our findings were observed immediately after a 3-month retention period when the expander was removed. Therefore, the possible recovery of the buccal bone plate might be a consequence of tissue recovery with time. Ten Hoeve and Mulie[53] demonstrated that, when incisor roots are moved lingually, the palatal cortex could not be detected immediately after the orthodontic treatment with laminagraphy. However, approximately 6 months later, a thin palatal cortex was registered, and, from 1 to 5 years posttreatment, the palatal cortex had remodeled and reshaped to resemble a normal cortex.

The periodontal consequences of RME in the permanent dentition highlight the importance of early intervention. During the deciduous and mixed dentition, RME produces a greater orthopedic effect[9,16] and transfers the anchorage to deciduous molars and canines. Despite the possibility of periodontal involvement, the future eruption of the permanent teeth will be followed by new alveolar bone, reestablishing the area's integrity.

This study should be complemented by longitudinal investigations on broader samples. Rapid and slow expansions at various biologic ages might also be evaluated with CT.

CONCLUSIONS

1. RME orthodontic effect reduced the BBPT of maxillary posterior teeth and increased the LBPT.
2. The tooth-tissue-borne expander caused less of an increase to the LBPT of the maxillary posterior teeth than did the tooth-borne expander.
3. RME induced bone dehiscences on the anchorage teeth's buccal aspect, especially in subjects with thinner buccal bone plates.
4. The tooth-borne expander produced more reduction of first premolar BACL than did the tooth-tissue-borne expander.

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