Cone-beam computed tomography evaluation of bone plate and root length after maxillary expansion using tooth-borne and tooth-tissue-borne banded expanders

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Introduction: The objective of this research was to evaluate the buccal bone plate and root length of maxillary permanent first molars using cone-beam computed tomography after maxillary expansion with different activation protocols. **Methods:** Cone-beam computed tomography images of growing patients were obtained from the orthodontic department of Pontifical Catholic University of Rio Grande do Sul in Brazil. The groups were Haas-type 2/4 turns, Haas-type 4/4 turns, hyrax-type 2/4 turns, and hyrax-type with alternate rapid maxillary expansions and constrictions (alt-RAMEC) 4/4 turns a day. Tooth length, periodontal insertion, alveolar bone thickness, and intermolar distances were evaluated. The data at the start of treatment and 6 months later were compared using generalized linear models. The intergroup differences were determined by univariate analysis of variance with the Bonferroni adjustment. **Results:** Tooth length was significantly shortened after expansion in all groups (−0.28 to −0.51 mm), except for the alt-RAMEC group. Bone level variables (bone level and bone level at the tooth tip) changed statistically in all groups, except for the Haas 4/4 turns group. There was significant periodontal attachment loss after rapid maxillary expansion with the hyrax/alt-RAMEC (5.09 mm). The hyrax/alt-RAMEC and hyrax groups had more dehiscences, fenestrations, and exposures of the root. **Conclusions:** The consequence of rapid maxillary expansion using the hyrax was alveolar bone resorption, especially in the hyrax/alt-RAMEC group, whereas the Haas expander caused mild root resorption. (Am J Orthod Dentofacial Orthop 2018;154:504-16)

The maxillary expansion procedure is widely used to correct posterior maxillary transverse discrepancies that are usually associated with different kinds of malocclusion, such as a Class II or Class III molar relationship, open bite, or crowding.[1-7] Early treatment of this condition offers the possibility of orthopedic correction by the separation of the midpalatal, circumzygomatic, and circumaxillary sutures. The aims of the transverse correction during the mixed dentition are to eliminate arch length discrepancies and basal bone deficiencies and to facilitate facemask protraction.[8-10] However, Liou and Tsai[8] proposed an alternative method for disarticulation of the circumaxillary sutures using alternate expansion and constriction (alt-RAMEC) of the maxillary arch. They reported that the maxillary sutures were less disarticulated using conventional rapid maxillary expansion (RME) compared with the alt-RAMEC method. In addition, the facemask therapy associated to the alt-RAMEC procedure was 3 times more effective to displace A-point anteriorly than with RME in a sample of growing Class III patients with cleft lip and palate.[8]

The orthopedic expansion is obtained when a high-force system is applied on the midsagittal maxillary suture using tooth-tissue-borne (Haas type) or tooth-

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borne (hyrax type) appliances. Heavy forces such as 10 kilogram-force generated during a turn of the expander screw[11] are responsible for transverse skeletal changes with suture opening and minimum orthodontic movement.[1,12,13]

The application of orthodontic forces induces a local process of inflammation, which is essential for tooth movement. This biomechanical reaction includes the 4 cardinal signs and symptoms of inflammation: redness, heat, swelling, and pain.[14] Although orthodontically induced root resorption is an undesirable risk of treatment, it is considered an unavoidable consequence of the forces applied for tooth movement.[14,15] No regeneration is possible when the tooth root loses apical tissue beneath the cementum layers[14]; however, root resorption severe enough to create a clinical problem is unusual in orthodontics.[16]

Previous studies have reported RME with root resorption and evaluated this phenomenon with different imaging techniques such as radiographs,[17] histologic analysis,[18,19] scanning electron microscope,[20] and cone-beam computed tomography (CBCT).[21] Conventional computed tomography and CBCT have also been used for skeletal, dentoalveolar, and periodontal change analyses resulting from maxillary expansion.[22-27] Some studies have indicated that RME can change the buccal cortical bone level[23,28,29] and cause root resorption,[21] but no studies have compared how different RME screw activation protocols can affect both bone level and root length.

The aim of this study was to evaluate the buccal bone plate and root length of maxillary permanent first molars using CBCT in 4 groups of patients, divided according to their treatment protocols for RME.

MATERIAL AND METHODS

The ethical committee of the Pontifical Catholic University of Rio Grande do Sul in Brazil approved this study. A sample of growing patients was selected from the database of previous randomized clinical trials in the Department of Orthodontics at the School of Dentistry, with random allocation of each subject to the groups.

The inclusion criteria for the study were transverse maxillary deficiency, mixed or early permanent dentition, and no surgical or other treatment that could interfere with the RME effects during the expansion period. Patients with congenital malformations, periodontal diseases, or metallic restorations in the permanent first molars were excluded.

CBCT images were taken before treatment (T1) and 6 months after jackscrew stabilization (T2). The images were taken using an i-CAT scanner (Imaging Sciences International, Hatfield, Pa) at 120 kV, 8 mA, scanning time of 40 seconds, and 0.3-mm voxel dimension. The data for each patient were saved in DICOM format, and the images were stored in compact disks.

The CBCT data of 77 patients of the original sample were analyzed, and 16 examinations were excluded because the roots of the permanent first molars were incomplete at the apical third when the initial CBCT were taken. Therefore, the total sample size of this study consisted of 61 children, distributed as described in Table I.

The patients were distributed in 4 groups, according to the daily screw activation protocol and expander appliances used for RME: Haas-type 2/4 turns (n = 11), Haas-type 4/4 turns (n = 16), hyrax-type 2/4 turns (n = 18), and hyrax-type with alternate rapid maxillary expansions and constrictions (alt-RAMEC) activation protocol with 4/4 turns a day (n = 16) (Table I).

A complete turn of the screw was done at the installation of the appliance in all groups (0.8 mm). The patients of the alt-RAMEC group were instructed to perform screw activation for a week and deactivation towards closing at the same daily rate over the next week. Maxillary expansions and constrictions were repeated for 7 weeks in this hyrax-type group.

Activations were performed until up to 8 mm of expansion in the Haas-type 2/4, Haas-type 4/4, and hyrax-type 2/4 groups. The alt-RAMEC group had a total of 6.4 mm of screw opening. Overcorrection of the transverse dentoskeletal discrepancy in all groups was achieved. At the end of the RME active phase, the screws were stabilized, and all patients used the same expanders for 6 months during the retention period.

The CBCT analysis was performed using the InVivo5 software program (Anatomage Dental, San Jose, Calif) as similarly proposed by Bernd.[30] The region of the permanent first molar was evaluated. The long axis of the mesiobuccal root of the maxillary permanent first molar was used as the reference for the standardization of the CBCT images taken at T1 and T2 (Fig 1; Table II).

In the axial view, using the Section mode tool in the InVivo5, the reference line (horizontal) available in the program was positioned at the center of the mesiobuccal root of the maxillary first molar (Fig 1, *A*). In the sagittal view, the reference line (vertical) was positioned on the long axis of the mesiobuccal root of the tooth (Fig 1, *B*), resulting in a coronal image with adequate visualization of the alveolar buccal cortical bone and molar root axis to be measured (Fig 1, *C* and *D*). Then the reference line (vertical) was also placed on the long axis of the mesiobuccal root of the maxillary first molar (Fig 1, *C*). The reference protocol for the CBCT analysis was based on the individual positioning of each tooth, and this step