Periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion appliances

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Introduction: The purposes of this study were to evaluate and compare the periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion devices using cone-beam computed tomography. **Methods:** Twenty-five patients requiring maxillary expansion were randomly allocated into 2 groups. A tooth-borne hyrax appliance was used in the first group, consisting of 13 patients (8 girls, 5 boys; mean age, 14.3 ± 2.3 years), and a tooth-bone-borne hybrid hyrax appliance was used in the second group of 12 patients (6 girls, 6 boys; mean age, 13.8 ± 2.2 years). Cone-beam computed tomography records were taken before and 3 months after expansion, and periodontal, dentoalveolar, and skeletal measurements were made on the cone-beam computed tomography images with a software program. The 2 independent-samples *t* test and the Mann-Whitney U test were used to evaluate treatment changes for both groups. Paired-samples *t* test and Wilcoxon test were used to compare the measurements at 2 time points for variables. **Results:** Significant skeletal changes and increases in interdental distances were observed in both groups. However, the distances between the first and second premolars increased more with the hyrax appliance (7.5 ± 4.2 and 7.9 ± 3.3 mm, respectively) than with the hybrid hyrax (3.2 ± 2.6 and 4.5 ± 3.8 mm, respectively) ($P < 0.05$). Similar reductions in buccal bone plate thickness and increases in palatal bone plate thickness of the anchored teeth occurred in both groups, whereas changes in buccal and palatal bone thicknesses of the left first premolars significantly differed between groups ($P < 0.001$). No significant intergroup difference was found in terms of absolute dental tipping. **Conclusions:** Both tooth-borne and tooth-bone-borne rapid expansion are effective methods for treating a narrow maxilla. However, the hyrax appliance resulted in greater expansion in the premolar region. On the other hand, the hybrid hyrax appliance did not cause changes in the bony support of the first premolars. (Am J Orthod Dentofacial Orthop 2015;148:97-109)

Transverse maxillary deficiency is a common orthodontic problem often seen in children. Early treatment with different protocols and various appliances is recommended to correct maxillary constrictions. One common method, rapid maxillary expansion (RME), described by Angell,[1] has been used for more than 150 years as a part of orthodontic treatment.

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The purposes of RME are to produce hyalinization in the periodontal ligament of the anchor teeth using heavy forces and to achieve maximum orthopedic and minimum orthodontic effects with the opening of the midpalatal suture.[2-4] Traditional tooth-borne RME devices are supported by the maxillary first premolars and first molars with bands or by the posterior teeth with acrylic. However, with tooth-supported expansion devices, it is not possible to obtain pure skeletal opening. Moreover, excessive buccal tipping of the posterior teeth, root resorption, gingival recession, buccal cortical bone thinning, and fenestration have been reported as undesirable effects.[5-8] Recent computed tomography (CT) studies have demonstrated decreases in buccal alveolar bone thicknesses of the supporting teeth after RME.[8,9] Garib et al[8] reported that the greatest bone dehiscences among the banded teeth were found at the first premolars. To overcome these disadvantages of tooth-borne expansion, the use of bone anchored RME appliances (transpalatal distractors) was proposed.[10,11] On the other hand,

the application and removal of transpalatal distractors to the palatal bone require an invasive surgical procedure and increase the risk of infections.[10-13]

A recently developed tooth-bone-borne appliance may be another option for RME.[13-15] This hybrid hyrax device, anchored to the first molars at the posterior and to the palate at the anterior with miniscrews, provides several advantages such as eliminating the need for invasive surgery, being more cost-effective, and reducing buccal tipping. Furthermore, it can be used in patients with inadequate anterior dental anchorage (missing deciduous teeth or premolars with underdeveloped roots).[14] A clinical study evaluating the effects of the hybrid hyrax combined with a facemask on 3-dimensional (3D) scans of dental models and also a finite element analysis showed its effectiveness for RME.[14,15] However, there is lack of information on its periodontal and skeletal effects in the current literature.

Lateral cephalometric, posteroanterior, and occlusal radiographs and dental casts have been used to diagnose transverse anomalies and evaluate changes in dentofacial structures after RME.[16-20] Factors including loss of data during the reduction of 3D objects into 2-dimensional (2D) images, superimposition of anatomic structures on radiographs, and internal and external orientation mistakes that influence the analysis of results render 2D radiologic methods inadequate in assessing the skeletal, dental, and periodontal effects of treatments. Three-dimensional volumetric imaging with cone-beam CT (CBCT) not only overcomes these limitations but also enables quantitative evaluation of alveolar bone thicknesses.[21]

The aims of this study were to evaluate and compare the periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion methods with CBCT.

MATERIAL AND METHODS

This prospective clinical study was carried out on patients who required maxillary expansion. The selection criteria were (1) unilateral or bilateral posterior crossbite and maxillary constriction; (2) no previous orthodontic treatment; (3) permanent dentition with no congenitally missing or extracted maxillary canines, premolars, and first molars; and (4) no systemic or genetic disease.

This study was approved by the institutional review board of Yeditepe University, Istanbul, Turkey (decision number 178). Informed consent was obtained from the parents.

Of 51 maxillary constriction patients referred to the orthodontic clinic at Yeditepe University during a 2-year period, 26 patients meeting the criteria and agreeing to participate were consecutively enrolled in the study. According to the order of referral with a randomization ratio of 1:1, they were randomly allocated to 2 groups by an orthodontist (D.G.-C.) who did not know in advance which treatment the next patient would get. One patient who lost the palatal miniscrews 2 days after insertion of the expander because of consuming hard foods was excluded from the study.

Table I. Comparison of age, activation time, and sex distribution between the groups

	Hyrax	*Hybrid hyrax*	P
Age (y)	14.3 ± 2.3	13.8 ± 2.2	0.6*
Activation time (d)	19.2 ± 4.5	20.2 ± 3.0	0.5*
Sex			0.6†
Male	5 (38.5)	6 (50)	
Female	8 (61.5)	6 (50)	

Values are mean ± SD or n (%).
*P values for 2 independent-samples t test; †P value for the Fisher exact test.

The mean ages and sex distributions of the groups are shown in Table I. The patients in the first group (8 girls, 5 boys; mean age, 14.3 ± 2.3 years) were treated with a traditional tooth-supported hyrax appliance attached to the maxillary first premolars and molars (Fig 1). The patients in the second group (6 girls, 6 boys; mean age, 13.8 ± 2.2 years) were treated with a tooth-bone supported hybrid hyrax appliance (Fig 2). Molar bands were fitted to the maxillary right and left first molars. Two miniscrews (Total Anchor; Trimed, Ankara, Turkey) with a 1.8-mm diameter and a 9-mm length were inserted using a physiodispenser after predrilling with a 1-mm drill at the level of the right and left first premolars, near the second and third palatal rugae, next to the midpalatal suture, under local anesthetic by the same operator (M.T.). Transfer caps were placed over the miniscrews, and a silicone impression was taken. After the laboratory analogs were inserted into the transfer caps, the model was obtained, and the hybrid hyrax was fabricated. The appliance was applied 7 days after placement of the miniscrews and bonded to the first molars by the bands and to the miniscrews by the caps (TTA S-cap; Trimed) using glass ionomer cement (Multi-Cure glass ionomer band cement; 3M Unitek, Monrovia, Calif). In both groups, the expansion screw was activated twice a day (a quarter turn in the morning and another quarter turn in the evening). In both groups, all patients showed a midpalatal suture split that was clinically detected. When the palatal cusp tips of the maxillary first molars were in contact with the corresponding buccal cusp tips of the mandibular first molars, expansion was completed. Then the