ORIGINAL ARTICLE CE AJO-DO

Differences in distances between maxillary posterior root apices and the sinus floor according to skeletal pattern

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Introduction: The aim of this study was to evaluate the distances from the maxillary posterior root apices to the inferior wall of the maxillary sinus using cone-beam computed tomography images and the relationships between roots and maxillary sinus according to age, sex, and skeletal pattern. **Methods:** Three-dimensional images of each root were checked, and the distances were measured along the true vertical axis from the apex of the root to the sinus floor in 118 patients (63 male, 55 female) aged 10 to 28 years. Compare-means statistic tests were done to assess the differences between groups classified according to age, sex, and skeletal pattern. **Results:** The frequency of root contact with the sinus floor increased from 70% at the second premolar to more than 80% at the buccal roots of the first and second molars. Male and older age (20-28 years) groups had significantly smaller distances or more protrusion of the root into the sinus than female and younger age (10-20 years) groups. The distances were shorter, or there was more protrusion of the root into the sinus in the hyperdivergent, down-canted palatal plane, and large gonial angle groups. **Conclusions:** Male, older age, hyperdivergent skeletal pattern, and large gonial angle groups had significantly closer distances between maxillary root tips and the sinus floor or more protrusion of the roots into the sinus. The intrusion of the maxillary molars in those situations may be difficult and slow because of the pneumatized maxillary sinus. (Am J Orthod Dentofacial Orthop 2017;152:811-9)

The paranasal sinuses develop as an aid to facial growth and architecture, or persist as residual remnants of an evolutionary structure. The biologic roles of these sinuses are debated, but a number of possible functions have been proposed, including lightening the weight of the head, humidifying and heating inhaled air, increasing the resonance of speech, providing a buffer against facial trauma, and aiding the immune defense for the nasal cavity.[1] The maxillary sinus is the largest paranasal sinus that overlies the maxillary alveolar process. It develops late in fetal life and ends its growth around 18 years of age.[2] Along with the sinus pneumatization process, the sinus floor moves inferiorly and becomes closer to the roots of maxillary teeth. In more than 50% of the population, the inferior sinus wall lies among the roots of the posterior maxillary teeth creating a "hillock" (elevation of the sinus floor) or protrusion of the roots into the sinus.[3,4] In this situation, the thickness of the bone layer of the sinus floor is reduced significantly. However, most roots that protrude into the sinus are actually enveloped by a thin cortical layer on histologic sections, and the rates of true perforation are only 14% to 28%.[3]

There are many studies concerning the vertical and horizontal relationships from maxillary posterior root apices to the inferior wall of the sinus and their effect on endodontic treatment, implant placement, tooth extraction, and sinusitis.[3-10] However, the impact of this relationship on orthodontic tooth movement has not received as much attention. Nowadays, with microimplant anchorage, molar intrusion has become more effective and efficient, but it is still considered a difficult procedure in orthodontics.[11] The maxillary sinus with its cortical bone layer is a natural barrier for the intrusion of the maxillary molars. The intrusion or bodily movement of posterior teeth across the maxillary sinus has been known to cause moderate apical root resorption and a higher degree of tipping.[12,13] There have

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, December 2016; revised and accepted, May 2017.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2017.05.021

been only a few studies assessing the correlation between size of the sinus and malocclusion type. Oktay[14] found that female subjects with Class II malocclusions had larger sinuses, whereas Endo et al[15] stated that there was no relationship between ANB angle and sinus size. However, no study has evaluated distances from the maxillary root tips to the sinus floor according to different skeletal patterns.

Cone-beam computed tomography (CBCT) provides an accurate evaluation of maxillary bone quality and quantity around the root apices of posterior teeth without distortion and overlapping of teeth with surrounding structures.[16,17] Howe[18] compared the amount of the bone around the root apices between CBCT and direct measurements with a physical caliper of 69 maxillary first molars in 37 cadaver specimens. The Pearson correlation had a coefficient of $r = 0.85$, showing that CBCT is reliable for measurements. Therefore, we used CBCT for measurements as did many previous studies.[6-9]

The aim of this study was to evaluate the distances from the root apices of the maxillary posterior teeth to the inferior wall of the maxillary sinus on CBCT images and the relationships among these distances and age, sex, and skeletal pattern.

MATERIAL AND METHODS

The data of patients who visited the Department of Orthodontics at Kyungpook National University Dental Hospital in Daegu, Korea, from 2011 to 2014 were checked, and patients with clear pretreatment CBCT images and cephalometric radiographs were included in this study.

This study was approved by the institutional review board of the university. The patients who had facial trauma, had received previous orthodontic treatment, had at least 1 congenital or acquired missing tooth in the posterior maxillary region, or had second premolars with 2 separated roots were excluded.

Finally, 118 patients (mean age, 17.78 ± 4.52 years; range, 10-28 years) were selected. The sample consisted of 63 male (mean age, 17.78 ± 5.00 years) and 55 female (mean age, 17.78 ± 4.52 years) subjects.

All measurements were done by 1 examiner (N.-L.A.). To classify the sample according to anteroposterior and vertical relationships, ANB angle, Frankfort-mandibular plane angle (FMA), Frankfort-palatal plane angle, and gonial angle were measured. The measurements on the cephalometric radiographs were carried out with V-Ceph dental software (version 6.0; Osstem, Seoul, Korea).

The sample was divided into subgroups, right and left sides, younger (age, 10-20 years) and older (age, 20-28 years) age groups, Class I (ANB, 0°-4°), Class II (ANB, ≥4°), and Class III (ANB, ≤0°) groups. The sample also was divided into hypodivergent (FMA, ≤23°), normodivergent (FMA, 23°-32°), and hyperdivergent (FMA, ≥32°) according skeletal divergency. According to the palatal plane (PP) cant to the Frankfort horizontal (FH) plane, the sample was divided into up-canted (FH-PP, ≤−2.5°), normal (FH-PP, −2.5°-2.5°), and down-canted (FH-PP, ≥2.5°) groups, where down-canted means that the PP is canted down anteriorly. In addition, the sample was divided into 3 groups according to gonial angle: large (≥129°), normal (117°-129°), and small (≤117°) gonial angle groups (Table I).

On the CBCT images, the distances from the root tips of the maxillary posterior teeth to the inferior wall of the sinus floor were measured. Hence, 7 roots per side were measured. The 3-dimensional (3D) measurements were done with InVivo software (version 5.2; Anatomage, San Jose, Calif). At first, the 3D constructed images were oriented with the FH plane aligned horizontally, where the FH plane was constructed by orbitale at the right side and porions on both sides. The coordinated images of each root in 3 coronal, axial, and sagittal planes were checked, and the sliced image passing the root apex was chosen for measurements. Thereafter, the shortest distances between the root tips of the teeth to the sinus floor wall were measured on the sliced image, if the roots had no contact with the sinus floor. If there were contacts between the roots and the sinus floor, the longest length from the root apices to the bottom of the sinus floor adjacent to the roots was measured. All distances from the root apices to the sinus floor were measured along the true vertical axis. The distances were recorded with positive values if there was no contact between the root and the sinus floor, and with negative values if the side of the root had contact with the sinus or the root protruded into the maxillary sinus (Fig). Immature roots with open apices were not included for measurements.

Statistical analysis

For the statistical analysis, SPSS software (version 22.0; IBM, Armonk, NY) was used. A normality test was done to check normal distribution of the sample, and all groups and subgroups showed normal distributions. To evaluate the differences in distances from the maxillary root tips to the sinus floor according to sides of evaluation, a paired *t* test was carried out. To evaluate differences according to age and sex, an independent *t* test was used. One-way analysis of variance (ANOVA) and the Tukey post hoc test were performed to