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Assessment of the Topographic Relationship Between the Maxillary Sinus and Maxillary Posterior Teeth Using Cone Beam Computed Tomography

Maksiller Posterior Dişler ile Maksiller Sinüs Arasındaki Topografik İlişkinin Konik Işınlı Bilgisayarlı Tomografi Kullanılarak Değerlendirilmesi

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ABSTRACT

Objective: The aim was to identify the distance between the apices of maxillary posterior teeth and maxillary sinus (MS) floor as well as the thickness of the bone between the root and the alveolar cortical plate.

Methods: The cone-beam computed tomography scans of 74 patients were evaluated retrospectively. Topographic measurements of the surrounding bone at the apex of all premolar and molar maxillary teeth were performed in 2 different planes (vertical and horizontal). A 1-way analysis of variance was used to determine the differences in linear measurements between each root for all tooth types and genders.

Results: The mean vertical distance to the MS floor was significantly high for first premolar roots and the lowest mean vertical distance was measured for mesio-buccal roots of second molars ($P < 0.05$). In contrast, the lowest buccal bone thickness was found for the first premolar, whereas the highest buccal thickness was measured for the mesiobuccal roots of the second molars ($P < .05$). When gender groups were evaluated separately, it was found that the vertical distance between the apices of second premolar teeth and the MS floor was significantly higher in females ($P < .05$). Moreover, the mesiobuccal and palatal horizontal measurements of second molars were higher in females ($P < .05$).

Conclusion: It is important to have knowledge about the linear measurements and morphological features of the maxillary alveolar bone in order to carry out successfull dental practices The obtained results were expected to be beneficial for clinicians to reduce the complication, especially in dental procedures involving maxillary molar region.

Keywords: Maxillary sinus, maxillary molar, maxillary premolar, topographic measurements

ÖZ

Amaç: Maksiller posterior dişlerin apeksleri ile maksiller sinüs (MS) tabanı arasındaki mesafenin belirlenmesinin yanında alveolar kemiğin kortikal tabakası ile kökler arasındaki kalınlığın saptanmasıdır.

Yöntemler: 74 hastaya ait konik ışınlı bilgisayarlı tomografi görüntüsü retrospektif olarak değerlendirildi. Maksiller premolar ve molar dişlerin apeksleri hizasındaki alveolar kemiğin 2 farklı düzlemde (vertikal ve horizontal) topografik ölçümleri yapıldı. Çalışmaya dahil edilen tüm diş tipleri ve cinsiyet grupları için her diş köküne yönelik yapılan doğrusal ölçümler arasındaki farklılıkları belirlemek amacıyla tek yönlü varyans analizi kullanıldı.

Bulgular: MS tabanına olan ortalama vertikal mesafe birinci premolar dişlerde anlamlı derecede yüksek iken, en düşük ortalama dikey mesafe ikinci molar dişlerinmezio-bukkal kökleri için ölçüldü ($P < 0.05$). Buna karşılık en düşük bukkal kemik kalınlığı birinci premolar dişler bölgesinde iken, en yüksek bukkal kemik kalınlığı ikinci molar dişlerin mezio-bukkal köklerinde ölçüldü ($P < .05$). Yapılan ölçümler cinsiyet dağılımına göre karşılaştırmalı olarak değerlendirildiğinde, ikinci premolar dişlerin apeksleri ile MS tabanı arasındaki vertikal mesafenin kadınlarda anlamlı şekilde daha yüksek olduğu belirlendi ($P < .05$). Ayrıca ikinci molar dişlerin mesio-bukkal ve palatal yöndeki horizontal ölçümleri kadınlarda anlamlı şekilde yüksekti ($P < .05$).

Sonuç: Maksiller alveol kemiğin morfolojik özellikleri ve doğrusal ölçümleri hakkında bilgi sahibi olunması, dental uygulamaların başarılı olarak gerçekleştirilebilmesi için önemlidir. Elde edilen sonuçların, özellikle maksiller posterior bölgeyi ilgilendiren dental işlemlerdeki komplikasyonların azaltılmasında klinisyenlere faydalı olması beklenmektedir.

Anahtar Kelimeler: Maksiller sinüs, maksiller molar, maksiller premolar, topografik ölçümler

INTRODUCTION

The proximity between the root apices of maxillary posterior teeth and the maxillary sinus (MS) floor may cause some inflammatory and traumatic changes in the MS.[1,2] It was proved that bacterial infection(s) spreading via bone marrow, blood vessels, and/or lymphatics into the MS might create various pathological alterations.[3-5] Accordingly, many iatrogenic complications have been reported during and/or after root canal treatment of the maxillary posterior teeth due to their close anatomical relationship.[6] Moreover, it is well known that extraction of teeth with root tips close to the MS floor may cause an oro-antral fistula. Bacterial inflammation originating from periapical lesions and/or endodontic/surgical complications has all been considered as a predisposing factor for odontogenic maxillary sinusitis.[7] Furthermore, the relationship between the maxillary posterior teeth and the MS should be determined to prevent the intrusion of dental implants into the MS. Therefore, accurate knowledge of the anatomic relationship between the root apices of maxillary posterior teeth and sinus floor is crucial for both non-surgical and surgical dental procedures.[8,9] One of the important factors that must be determined during the planning of surgical procedures for the maxillary posterior region is the thickness of buccal and palatal bone in the area of operation. Knowledge of the buccal and/or palatal bone thickness before endodontic surgery is essential for the decision of the optimal surgical site and surgical approach, as well as the selection of the most appropriate implant width.[10,11]

Three-dimensional (3D) imaging methods and, recently, cone-beam computed tomography (CBCT) have become the standard for the evaluation of both hard and soft tissue components of the MS. It was reported that CBCT imaging facilitates the decision to perform the surgery either from the buccal or from the palatal side.[9,11,12] Moreover, the detailed 3D information provided by multiple thin sections of CBCT also facilitates the clinicians' understanding of the topography of the adjacent anatomical structures, thereby increasing the success of surgical procedure(s).[8]

Many studies have been conducted to evaluate the topographic relationship between the roots of maxillary posterior teeth and the MS floor.[8,11,13] However, reported findings were not comparable because some studies used low-resolution CT devices, while others preferred cone-beam CT.[10,13-15] Moreover, some studies included the evaluation of the relationship of the sinus floor with both the premolar and the molar root apices, while others only included the molar roots.[13,16] Furthermore, most of the studies did not include the measurement of bone thickness around root apices. Only 2 studies determined the distance between the apices of the all-maxillary posterior teeth and the sinus floor, including the measurement of the buccal and palatal bone thickness using CBCT images.[9,11]

Therefore, the objectives of this study were to identify the distance of the apices of maxillary premolar and molar teeth to the MS floor and the morphological features of the alveolar bone surrounding the related root apices using cone-beam CT images.

MATERIAL AND METHODS

Study Sample

Ethics Committee of the Ege University approved this study (Date: 29.12.2016, Number: 70198063-16-11.1/10) as regards the 1964 Declaration of Helsinki. Informed consent was obtained from all participants.

Cone-beam computed tomography scans taken for various diagnostic purposes at the Department of Oral and Maxillofacial Radiology between 2018 and 2019 were examined retrospectively. Cone-beam computed tomography scans of 400 patients were obtained, and 74 scans showing at least 1 exposed MS as well as first and second premolars and molars without any malformations or bony pathologies were chosen and included in the study. The exclusion criteria for the study were the following: patients with apical pathologies, total edentulism, bone lesions related to systemic diseases, tumors in the maxillary posterior region, and images with heavy artifacts.

The CBCT images were obtained using the Kodak 9000 3D (Carestream Health Inc., Rochester, NY, USA) system with the following settings: field of view 50x37 mm, a voltage of 70 kVp, and a tube current of 10 mA. Small volumes were particularly preferred for high-resolution images (76 μm). DICOM files of the selected volumes were transferred to a portable hard disk for measurement sessions.

Topographic Measurements

Cross-sectional images were used for all measurements. Topographic measurements of the surrounding bone at the apex of all premolar and molar teeth were performed in 2 different planes (vertical and horizontal) consistent with the method of Yoshimine et al[32] using the native software of the CBCT system (CS 3D Viewer Software, Carestream Kodak 9300 C; Rochester, New York, USA). Both measurements were accomplished on the axial and sagittal section images reconstructed by the medial line of the root crown at the maxillary premolar and molar teeth (Figure 1). Since bone thickness is not similar in male and female subjects, the measurements for 2 genders were separately evaluated.

Vertical measurements (distance between root apex and sinus floor) were performed from the root apex to the inferior cortical border of the MS along the longitudinal axis of the root for all

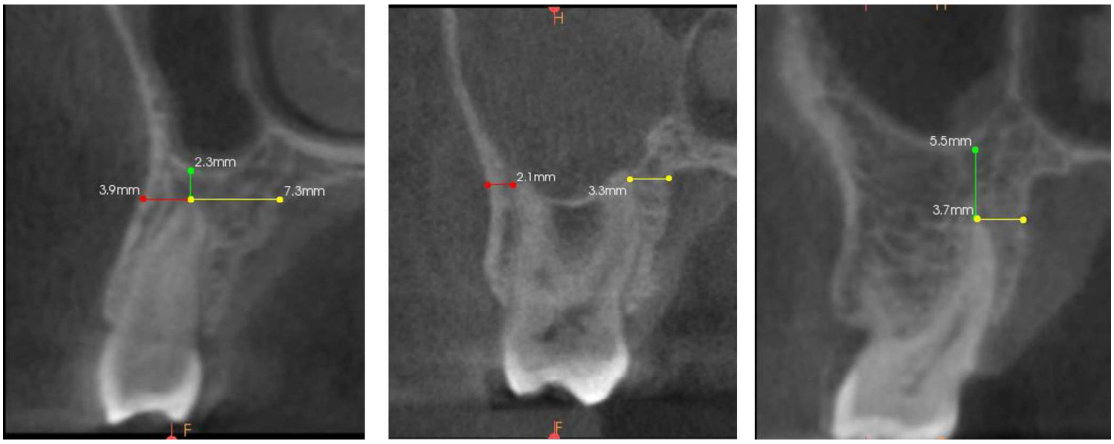

Figure 1. Cross-sectional cone-beam computed tomography images showing the vertical (green lines), buccal horizontal (red lines), and palatal horizontal (yellow lines) measurements of the alveolar bone areas around premolar and molar roots.

posterior maxillary teeth. Vertical measurements for molar teeth included the measurement of the distances from all [mesiobuccal vertical (MBV) and distobuccal vertical (DBV) and palatal vertical (PV)] root apices to the inferior cortical border of the MS, while vertical measurements of the premolar teeth were performed by measuring the distance from all root apices to the inferior cortical border of the MS (BV and PV) (Figure 1). Measurements were performed separately for each root of the maxillary posterior teeth and were recorded as “0” when the root apex touches the floor of MS.

Horizontal measurements were performed to determine the buccal and palatal bone thicknesses. Buccal bone thickness for molar teeth was measured as the horizontal distance between the buccal root apex and the outermost border of the buccal cortical plate along the longitudinal axis of the mesiobuccal horizontal (MBH) and distobuccal horizontal (DBH) roots, while the horizontal distance between the buccal root apex and the outermost buccal cortical border was measured for premolars (buccal horizontal, BH). The horizontal distance between the apex of the palatal root and the outermost border of the palatal cortical plate was recorded as the palatal bone thickness. Horizontal measurements for premolar and molar teeth were determined as the horizontal distance between the root apex and palatal surface of the alveolar bone separately (PH) (Figure 1). When there was no trabecular alveolar bone surrounding the root apices on buccal/palatal surfaces, horizontal measurement(s) were recorded as “0.”

All measurements were done by a single oral and maxillofacial radiologist who had 10 years of experience in CBCT imaging. Measurements were repeated by the same evaluator after 2 weeks.

Statistical Analysis

All data were descriptively analyzed using Statistical Package for Social Science Statistics version 15.0 software (SPSS Inc.; Chicago, IL, USA). Means, SDs, and minimum and maximum values of the vertical and horizontal measurements were calculated for all tooth types and all roots. A 1-way analysis of variance was used to determine the differences in linear measurements between each root for all tooth types and genders. All premolar teeth included in the study were single-rooted. Accordingly, pairwise comparisons of bone thicknesses were done between measurements of the single root of premolars, while each root of the molar teeth was compared separately. Pairwise comparisons were performed by the least significant difference test. In order to calculate intra-examiner agreement, Cohen’s kappa coefficient (κ) was used and scored according to the Landis and Koch scale (0.0-0.2; slight agreement; 0.21-0.40; fair agreement; 0.41-0.60; moderate agreement; 0.61-0.80; substantial agreement; and 0.81-1.0; almost perfect). A P -value less than .05 (typically $\leq$.05) was statistically significant. At the end of the study, a “post hoc” power analysis was conducted to justify the chosen sample size using the G*Power software version 3.1 (Düsseldorf University, Germany).

RESULTS

A total of 164 posterior teeth were assessed in 74 patients (males: 56.8%, females: 43.2%, mean age: 48.6 years). Among 164 teeth, 80 (48.8%) were premolars, while 84 (51.2%) were molars. Among the evaluated teeth, 42 teeth were first (25.6%), 38 teeth were second (23.2%) premolars, while 44 teeth were first (26.8%), and 40 teeth were second (24.4%) molars. The total number of evaluated roots was 332. The mean and SDs of a total of 744 horizontal

Table 1. Vertical Measurements Between Maxillary Posterior Teeth Roots and the Sinus Floor (mm)

Vertical (V) Measurement, mm (Mean ± SD)	First Premolar	Second Premolar	First Molar			Second Molar		
Root	BV=PV	BV=PV	MBV	DBV	PV	MBV	DBV	PV
Total	4.98 ± 0.8*†	2.18 ± 0.60*	1.70 ± 0.56*¶	1.45 ± 0.48*¶	1.40 ± 0.40*¶	0.62 ± 0.26*†¶	1.40 ± 0.77*	1.35 ± 0.95*
Female	5.56 ± 1.32	3.22 ± 0.90‡	1.87 ± 0.94	1.55 ± 0.89	1.58 ± 0.60	0.35 ± 0.22	3.35 ± 3.35	2.10 ± 1.78
Male	4.20 ± 1.08	0.75 ± 0.38‡	1.54 ± 0.68	1.35 ± 0.48	1.25 ± 0.56	0.74 ± 0.36	2.40 ± 077	2.44 ± 1.17

BV, buccal vertical; DBV, distobuccal vertical; MBV, mesiobuccal vertical; PV, palatal vertical. According to the least significant difference test ($P < .05$):
*shows the significant difference between distances of molar and premolar roots to the sinus floor.
†shows the significant difference between the distances of first premolar roots and mesiobuccal roots of second molars to the sinus floor.
¶shows the significant difference between the distances of mesiobuccal roots of second molars and all roots of first molars to the sinus floor.
‡shows the significant difference between gender groups for vertical measurements of second premolar.

Table 2. Horizontal Measurements Between Maxillary Posterior Teeth Roots and Buccal/Palatal Cortical Bone Plate (mm)

Horizontal (H) Measurement, mm [Mean ± SD]	First Premolar		Second Premolar		First Molar			Second Molar		
Root	BH	PH	BH	PH	MBH	DBH	PH	MBH	DBH	PH
Total	0.65 ± 0.15*†	4.97 ± 0.47‡	1.69 ± 0.30*†	5.25 ± 0.25‡	1.07 ± 0.29*†¶	2.01 ± 0.36*†	1.85 ± 0.38‡^	3.85 ± 0.26*†¶	2.38 ± 0.44*	3.03 ± 0.49‡^
Female	0.78 ± 0.21	5.22 ± 0.66	1.78 ± 0.45	5.43 ± 0.37	1.39 ± 0.50	2.71 ± 0.63	2.34 ± 0.58	5.13 ± 0.39&	3.25 ± 0.75	4.43 ± 0.60β
Male	0.48 ± 0.19	4.64 ± 0.67	1.57 ± 0.41	5.02 ± 0.34	0.76 ± 0.29	1.30 ± 0.26	1.35 ± 0.46	3.30 ± 0.22&	2.22 ± 0.50	2.39 ± 0.60β

BH, buccal horizontal; DBH, distobuccal horizontal; MBH, mesiobuccal horizontal; PH, palatal horizontal.According to the least significant difference test ($P < .05$):
*shows the significant difference between buccal horizontal thicknesses of first premolars and other teeth.
†shows significant difference between mesiobuccal horizontal thicknesses of second molar and other teeth.
¶shows significant difference between mesiobuccal horizontal thicknesses of second molar and first molar.
&shows the significant difference between gender groups for mesiobuccal horizontal thicknesses of second molar.
‡shows significant difference between palatal horizontal thicknesses of premolars and molars.
^shows significant difference between palatal horizontal thicknesses first molar and second molar.
βshows the significant difference between gender groups for palatal horizontal thicknesses of second molar.

and vertical measurements are shown in Tables 1 and 2. Post-hoc power calculations at the level of α error probability = 0.05 indicated that the sample size is sufficient with 1.000 power and 2.473 effect size.

All premolar teeth included in the study were single rooted; therefore, a single vertical measurement was made by measuring the distance from the root apex of premolar teeth to the inferior cortical border of the MS, not separately from the buccal and palatal regions (BV = PV). The mean vertical distance measured between the root apices and inferior cortical border of the MS for the first and second premolar roots was compared with each root of the molar teeth. According to this comparison, the mean vertical measurements were smaller for all roots of the first and second molar teeth as compared to the first and second premolar roots ($P < .05$). The mean vertical distance to the MS floor was significantly greater for first premolar roots (4.98 ± 0.87 mm), whereas the lowest mean vertical distance was measured for the mesiobuccal roots of second molars (0.62 ± 0.26) ($P < .05$). When molar teeth were compared with each other, no difference was found between the vertical distances of distobuccal and palatal roots of first and second molar teeth and MS floor ($P > .05$). However, vertical distance between the MS floor and mesiobuccal roots of second molars was smaller than that of the first molar teeth ($P < .05$) (Table 1).

For pairwise comparisons of bone thickness measurements, the buccal bone thickness of premolars (BH) was compared with the buccal bone thickness of MBH and DBH molar roots separately. The lowest buccal bone thickness was found for the first premolar, whereas the highest buccal thickness was measured for the MB roots of the second molars ($P < .05$). When molar teeth were compared with each other as regards MB and DB roots separately, no difference was found between DBH measurements of the first and second molars ($P > .05$). However, MBH measurements of the second molar teeth were higher than those of the first molars ($P < .05$). Palatal horizontal thicknesses of the first and second premolar teeth were significantly higher than the PH thicknesses of all molar teeth ($P < .05$). Further, according to the molar teeth comparison, the PH thickness of the second molars was significantly higher than that of the first molars ($P < .05$) (Table 2).

When gender groups were evaluated separately, it was found that the vertical distance between the apices of second premolar teeth and the MS floor (BV = PV) was significantly higher in females ($P < .05$). Moreover, the MBH and PH measurements of second molars were significantly higher in females ($P < .05$). No statistically significant difference was found in the remaining measurements between genders (Tables 1 and 2).

The kappa analysis revealed that intra-examiner agreement ranged from good to almost perfect (range: 0.51-0.84).

DISCUSSION

Clinicians' knowledge about the relationship between the roots of posterior maxillary teeth and the alveolar bone surrounding the roots provides advantages for the success of many dental procedures, such as implant treatment, apicoectomy (endodontic surgery), and applications of orthodontic mini implants.[9,10] Many studies have been carried out to evaluate the relationship between the posterior maxillary teeth and adjacent structures.[9,11,14,17,18] Previous studies evaluating this relationship with different imaging modalities showed that the root apices of the maxillary molar teeth are generally very close to the MS floor as compared to the premolar teeth.[9,11,14,17,18] When the linear measurements in previous studies were evaluated according to specific tooth groups, it was seen that the shortest vertical distance to the MS floor was measured in maxillary second molars, whereas the furthest vertical distance was in first premolars. [9,11,14,17,18] In addition, most of the studies reported that the root closest to the floor of the MS is the mesiobuccal root of the second molar tooth.[11,17] Even though the results reported here support these findings, the measurement values obtained were higher than some of the existing studies.[19] Similar to previous studies, [9,11,17,18] only the coronal slices were used for all measurements in the present study. However, studies that performed measurements on CBCT images in 3 different planes found that measurements of all roots in the coronal planes were higher than those in the sagittal planes.[19] This difference between measurement values in various studies may be explained with CBCT slices (coronal or sagittal) selected by researchers to perform the measurements.

The results of the present study revealed that the distance between the root of the molar and sinus floor was the shortest for the mesiobucal roots of maxillary second molars. This finding confirms the possible complications related to the proximity of the second molars to the floor of the MS that may occur during surgical operations. Displacement of dental implant or roots into the MS, perforation of the MS floor (oroantral communication) during tooth extraction, and dental material extrusion used in root canal therapy can be considered among these complications.[9] It has been shown that sufficient alveolar bone is a prerequisite for long-term dental implant success.[20,21] However, many studies showed that the success rate for maxillary implants was less than that for mandibular implants because of the limited amount of bone volume and the MS pneumatization after tooth loss.[21] Maxillary sinusitis caused by dental implant insertion into the MS and projection of the dental implant into the MS cavity were the possible complications of dental implants that may occur at the maxillary region.[22] The risk of developing these complications in the second molar region increases due to the proximity of the second molars to the floor of the MS. Therefore, it is essential to determine the anatomical relationships of the maxilla with a specific assessment of linear measurements for proper dental implant treatment in the maxilla.

Another important clinical problem encountered due to the vertical anatomical relationship between the roots of posterior teeth and MS is odontogenic maxillary sinusitis.[23] Considering that maxillary molars have a high periapical lesions risk compared to other tooth types, the periapical inflammation, especially in the buccal roots of molar teeth, can spread to the MS and cause odontogenic maxillary sinusitis.[1,9] The relationship between these anatomical structures should be considered to prevent an iatrogenic procedure and to minimize the risks of an infectious disease within the sinus. Therefore, clinicians should consider the possibilities of the above-mentioned complications during surgical and non-surgical treatments, especially for the buccal roots of second molar teeth.

In addition to the closeness to the MS, bone thickness surrounding the related root apices is an important factor during surgical operations. Information about anatomical structures is crucial for apicoectomy because visualization and access to the surgical site can be compromised when this information is missing. To date, it has been reported that the root apex closest to the buccal bony surface was the buccal root of the maxillary first premolar tooth, whereas the second molar was farthest from the buccal bony surface.[10,14] Although the findings obtained in this study were similar to the previous ones, the measurement values obtained for both buccal and palatal bone thickness were found to be higher than some of the existing studies.[11] The variation observed in bone thickness measurements in these studies can be attributed to the difference in the measurement regions. It has been shown that measurements performed at 3.0-mm resection level resulted in lower bone thickness measurement values as compared with the measurements at the apex level.[11] However, studies that performed measurements at the apex level confirmed that bone thickness in the apical region is relatively thicker than at the resection level,[8,10] as in our study.

It is well known that the thickness of buccal and palatal alveolar bones in the operation field is a crucial factor regarding both apical surgery and dental implantation.[13] Studies have proven that buccal horizontal bone thickness is lower than the palatal bone thickness in the premolar region,[9,13,24] which is in accordance with the findings of the present study. Although this fact may favor the buccal side for the surgical access of premolar teeth, in a clinical situation requiring the resection of the palatal root, the palatal plate may be more accessible, necessitating knowledge of the thickness of both buccal and palatal plates.[10,13] Moreover, the classical view for apical surgeries in the maxillary molar region is to perform the operations with a labial or buccal approach. However, recent studies evaluating the success rates of apical surgeries recommend a palatal approach for molar teeth in some special cases.[13] These findings once again reveal that the bone thickness surrounding tooth apices should be established before surgical procedures. In addition to endodontic surgical procedures, the measurement of the buccal and palatal bone thickness around root apices is important for implants' long-term stability and the aesthetics of the prosthetic superstructure. At this point, the dimensions of alveolar bone at the maxillary premolar region are critical, with the lowest horizontal bone thickness. Thus, clinicians should avoid traumatic extraction of maxillary first premolars, which may damage the thin buccal alveolar bone.[9]

Buccal and palatal bone plate thickness has vital importance not only for dental implant treatment in prosthetic rehabilitation but also for mini-implant placement for orthodontic purposes.[9,11,13] Mini-implants, also called the temporary anchorage devices [TADs], are utilized to provide intraoral orthodontic anchorage.[25] Factors affecting the stability of mini-screw implants include age, gender, site and side of implantation, as well as the craniofacial skeletal structure of the implantation area. At this point, alveolar bone thickness is important in terms of both selecting the proper implantation placement and safe insertion of mini-implants without any damage to anatomic structures such as blood vessels, teeth roots, and nerves.[26] The findings of the present study confirmed previous studies demonstrating the thickest bone over MB root of second molar[9,13,24] Thus, it has been considered that the maxillary buccal molar region is a proper and safe site for placement of mini-implants.

When the anatomical relationships assessed in our study were evaluated separately according to gender groups, it was noteworthy that females tended to have their premolar roots more distant from the MS compared to males. This finding can be explained by the fact that the premolar roots are generally longer in men than in women, and the MS shows larger dimensions on average in males than in women. The fact that the MS is larger on average in men than in women may be another explanation for this finding.[19] When the measurements made in the horizontal direction were evaluated according to gender differences, both the buccal and palatal bone thickness of the second molars in females were found to be significantly larger than those in males. Comparative analysis of tooth size discrepancies between males and females in several studies showed that females had statistically significantly smaller teeth than males.[27,28] It was thought that this may be the possible reason why both buccal and palatal bone thicknesses of molars were greater in females compared to males in the present study.

Previous radiographic studies evaluating the anatomical relationship between the maxillary posterior teeth and the alveolar bone have utilized many imaging modalities, such as panoramic radiographs, CT scans, or CBCT imaging modalities.[15,29] In this study, due to its capability to provide submillimeter accuracy, a CBCT imaging system was preferred for the linear measurements of the maxillary posterior region. Furthermore, it requires a shorter acquisition time, a reduced cost, and a lower radiation dose compared to conventional CT.[30,31] Since smaller voxel sizes and limited volume (field of view-FOV) scanning protocols provide better spatial resolution and diagnostic accuracy in CBCT imaging, it has been suggested that images obtained with a CBCT device with these technical features should be preferred for periapical region evaluations.[30] Studies investigating the efficacy of CBCT in performing orthodontic analyses have emphasized that images with a voxel size of less than 0.3 mm are required to detect minimal changes in bone thickness.[32] Similarly, Lavasani et al[17] stated that the most important limitation of their study was that the voxel size of the images they used was significantly larger than the limited-field CBCT scans, which was offered at as low as 0.076 mm. At this point, using a CBCT device with an FOV of 50 × 37 mm and a voxel size of 0.076 mm in the present study provided a high-resolution image, allowing measurements to be made with high accuracy. However, including only single-rooted premolars and a single population may be regarded as a limitation of this study for drawing generalized assumptions. Further multicenter studies, including many populations and double-rooted premolars, may provide more accurate results reflecting the true morphological characteristics of the maxillary posterior region.

This CBCT-based study evaluated the relationship between the maxillary posterior tooth roots, surrounding alveolar bones, and MS. The presented findings may be useful for clinicians performing dental interventions such as mini-implant placement, dental implant treatment, and apical surgery involving the maxillary posterior region.

Ethics Committee Approval: Ethics committee approval was received for this study from Ege University (Date: 29.12.2016, Number: 70198063-16-11.1/10).

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REFERENCES

1. American Association of Endodontists Position Statement. *Maxillary Sinusitis of Endodontic Origin*; 2018. Available at: https://www.aae.org/specialty/communique/maxillary-sinusitis-of-endodontic-origin/
2. Brook I. Sinusitis of odontogenic origin. *Otolaryngol Head Neck Surg*. 2006;135(3):349-355. [CrossRef]
3. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. *Clin Oral Implants Res*. 1997;8(3):161-172. [CrossRef]
4. Cassetta M, Sofan AA, Altieri F, Barbato E. Evaluation of alveolar cortical bone thickness and density for orthodontic mini-implant placement. *J Clin Exp Dent*. 2013;5(5):e245-e252. [CrossRef]
5. Eberhardt JA, Torabinejad M, Christiansen EL. A computed tomographic study of the distances between the maxillary sinus floor and the apices of the maxillary posterior teeth. *Oral Surg Oral Med Oral Pathol*. 1992;73(3):345-347. [CrossRef]
6. Georgescu CE, Rusu MC, Sandulescu M, Enache AM, Didilescu AC. Quantitative and qualitative bone analysis in the maxillary lateral region. *Surg Radiol Anat*. 2012;34(6):551-558. [CrossRef]
7. Golshah A, Moradi P, Nikkerdar N. Efficacy of micro-osteoperforation of the alveolar bone by using mini-screw for acceleration of maxillary canine retraction in young adult orthodontic patients: a split-mouth randomized clinical trial. *Int Orthod*. 2021;19(4):601-611. [CrossRef]
8. Guidelines on CBCT for dental and maxillofacial radiology. *Sedentexct Project*; 2012. Available at: https://www.sedentexct.eu/content/guidelines-cbct-dental-and-maxillofacial-radiology.
9. Gürhan C, Şener E, Mert A, Şen GB. Evaluation of factors affecting the association between thickening of sinus mucosa and the presence of periapical lesions using cone beam CT. *Int Endod J*. 2020;53(10):1339-1347. [CrossRef]
10. Jin GC, Kim KD, Roh BD, Lee CY, Lee SJ. Buccal bone plate thickness of the Asian people. *J Endod*. 2005;31(6):430-434. [CrossRef]
11. Joung L, Wong R. Tanaka–Johnston mixed dentition analysis for Southern Chinese in Hong Kong. *Angle Orthod*. 2006;76(4):632-636. [CrossRef]
12. Jung J, Choi B, Jeong S, Li J, Lee S, Lee H. The effects of exposing dental implants to the maxillary sinus cavity on sinus complications. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2007;103(5):623-625. [CrossRef]
13. Jung YH, Cho BH. Assessment of the relationship between the maxillary molars and adjacent structures using cone beam computed tomography. *Imaging Sci Dent*. 2012;42(4):219-224. [CrossRef]
14. Kang M, Kim E. Healing outcome after maxillary sinus perforation in endodontic microsurgery. *J Korean Dent Sci*. 2016;9(1):28-34. [CrossRef]
15. Kilic C, Kamburoglu K, Yuksel SP, Ozen T. An assessment of the relationship between the maxillary sinus floor and the maxillary posterior teeth root tips using dental cone-beam computerized tomography. *Eur J Dent*. 2010;4(4):462-467. [CrossRef]
16. Kwak HH, Park HD, Yoon HR, Kang MK, Koh KS, Kim HJ. Topographic anatomy of the inferior wall of the maxillary sinus in Koreans. *Int J Oral Maxillofac Surg*. 2004;33(4):382-388. [CrossRef]
17. Lavasani SA, Tyler C, Roach SH, McClanahan SB, Ahmad M, Bowles WR. Cone-beam computed tomography: anatomic analysis of maxillary posterior teeth-impact on endodontic microsurgery. *J Endod*. 2016;42(6):890-895. [CrossRef]
18. Leung EMY, Yang Y, Khambay B, Wong RWK, McGrath C, Gu M. A comparative analysis of tooth size discrepancy between male and female subjects presenting with a Class I malocclusion. *ScientificWorldJournal*. 2018;2018:Article ID 7641908. [CrossRef]
19. Lin L, Yifan F, Shihui H, Ziya L, Jianping G. *An Analysis of the Relationship between the Maxillary Molars and the Maxillary Sinus Floor in Adult Patient Using Cone-Beam Computed Tomography*; 2020. [CrossRef]
20. Molen AD. Considerations in the use of cone-beam computed tomography for buccal bone measurements. *Am J Orthod Dentofacial Orthop*. 2010;137(4):S130-S135. [CrossRef]
21. Nunes CA, Guedes OA, Alencar AH, Peters OA, Estrela CR, Estrela C. Evaluation of periapical lesions and their association with maxillary sinus abnormalities on cone-beam computed tomographic images. *J Endod*. 2016;42(1):42-46. [CrossRef]
22. Ok E, Güngör E, Colak M, Altunsoy M, Nur BG, Ağlarci OS. Evaluation of the relationship between the maxillary posterior teeth and the sinus floor using cone-beam computed tomography. *Surg Radiol Anat*. 2014;36(9):907-914. [CrossRef]
23. Pagin O, Centurion BS, Rubira-Bullen IR, Alvares Capelozza AL. Maxillary sinus and posterior teeth: accessing close relationship by cone-beam computed tomographic scanning in a Brazilian population. *J Endod*. 2013;39(6):748-751. [CrossRef]
24. Porto OCL, Silva BSF, Silva JA, et al. CBCT assessment of bone thickness in maxillary and mandibular teeth: an anatomic study. *J Appl Oral Sci*. 2020;28:e20190148. [CrossRef]
25. Rigolone M, Pasqualini D, Bianchi L, Berutti E, Bianchi SD. Vestibular surgical access to the palatine root of the superior first molar:

"low-dose cone-beam" CT analysis of the pathway and its anatomic variations. *J Endod*. 2003;29(11):773-775. [CrossRef]
26. Saruhan N. Foreign material in a maxillary sinus as a complication of root canal treatment: a case report. *Turk Endod J*. 2016:96-98. [CrossRef]
27. Shanbhag S, Karnik P, Shirke P, Shanbhag V. Association between periapical lesions and maxillary sinus mucosal thickening: a retrospective cone-beam computed tomographic study. *J Endod*. 2013;39(7):853-857. [CrossRef]
28. Sharan A, Madjar D. Correlation between maxillary sinus floor topography and related root position of posterior teeth using panoramic and cross-sectional computed tomography imaging. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2006;102(3):375-381. [CrossRef]
29. Sharan A, Madjar D. Maxillary sinus pneumatization following extractions: a radiographic study. *Int J Oral Maxillofac Implants*. 2008;23(1):48-56.
30. Vidal F, Coutinho TM, Carvalho Ferreira D, Souza RC, Gonçalves LS. Odontogenic sinusitis: a comprehensive review. *Acta Odontol Scand*. 2017;75(8):623-633. [CrossRef]
31. von Arx T, Fodich I, Bornstein MM. Proximity of premolar roots to maxillary sinus: a radiographic survey using cone-beam computed tomography. *J Endod*. 2014;40(10):1541-1548. [CrossRef]
32. Yoshimine S, Nishihara K, Nozoe E, Yoshimine M, Nakamura N. Topographic analysis of maxillary premolars and molars and maxillary sinus using cone beam computed tomography. *Implant Dent*. 2012;21(6):528-535. [CrossRef]