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Research Paper: Evaluating the Distance Between Posterior Teeth and the Maxillary Sinus Floor Using Cone Beam Computed Tomography

Zahra Tafakhori[1]*, Mahmood Sheikhfathollahi[2], Somayeh Nemati[3]

1. Associated Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.
2. Assistant Professor, Department of Epidemiology and Biostatistics and Occupational Environment Research Center, School of Medical, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.
3. Assistant professor, Department of Oral and Maxillofacial Radiology, Faculty of Dentistry and Dental Research Center, Guillan University of Medical Sciences, Rasht, Iran.

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ABSTRACT

Introduction: The topography of the sinus floor and its relationship with maxillary teeth roots vary with age, pneumatization size and grade, positioning of the teeth, and genetics. Objectives: This study used Cone-Beam Computed Tomography (CBCT) to evaluate the distance between posterior teeth and the maxillary sinus floor in patients of Rafsanjan, Iran.

Materials and Methods: This descriptive cross-sectional study evaluated 35 CBCT radiographs of patients over 20 years old, who were referred to a private oral and maxillofacial radiology clinic in Rafsanjan for dentistry procedures. CBCT imaging was performed. After obtaining Multi-Planar Reformatted (MPR) images, a maxillofacial radiologist measured the vertical relationships between all roots of posterior maxillary teeth and the maxillary sinus floor and classified them as described by Didilescu et al. The collected data were analyzed by SPSS V. 21.

Results: Generally, the distobuccal root of the second molars had the shortest distance from the maxillary sinus floor. The statistical tests showed no significant relationships among the measured distances and age, gender, or the assessed region.

Conclusion: Since the distance between posterior maxillary teeth and maxillary sinus floor was mostly type 0 in the population of Rafsanjan, clinicians are recommended to use CBCT to obtain adequate knowledge of anatomy and morphological details of tooth roots before any treatment, especially surgical procedures.

*** Corresponding Author:**
Zahra Tafakhori, MD.
Address: *Department of Oral and Maxillofacial Radiology, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran.*
Tel: *+98 (34) 34280031*
E-mail: *ztafakhori@yahoo.com*

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1. Introduction

The maxillary sinus is the first paranasal sinus to develop and its development ends by 20 years of age [1]. With the eruption of the permanent teeth, the sinus begins to pneumatize into the alveolar ridge. At the age of 12 or 13, the sinus floor reaches the same level as the nasal floor, and at the age of 20, sinus pneumatization stops following the complete eruption of the third molars [2]. The size and development of sinus are different in different people. In half of the population, the sinus floor develops between roots, causing an elevation at sinus antral level or protrusion of roots into the sinus. In such cases, the thickness of the sinus floor is significantly reduced [3]. After the extraction of a tooth, sinus dilatation significantly decreases the amount of bone available for implantation [1].

Other complications caused by the projection of roots into the sinus include oroantral fistula (the extension of the root into the sinus following the extraction of the first and second molars) and the endoanteral syndrome (the progression and development of pulpal diseases into the sinus, causing sinusitis). Therefore, the careful assessment of the anatomic relationship of maxillary sinuses with the roots of posterior teeth is essential for the diagnosis of maxillofacial pathologies and preoperative treatment plans. The diagnosis of sinus disease of odontogenic origin is not easy and creates uncertainty in not only patients but also physicians and dentists [4]. The most common causes of sinus disease of odontogenic origin are tooth abscess and periodontal diseases, which perforate Schneider membrane, stimulate the sinus with interantral foreign objects, and ultimately lead to the secondary infection of the sinus [5].

The topography of the sinus floor and its relationship with maxillary teeth roots depend on age, pneumatization size and grade, the position of teeth, and genetics [6, 7]. The relationship between the roots of posterior maxillary teeth and maxillary sinus can be investigated by various radiographic techniques, including two-dimensional (e.g. panoramic and periapical) methods or three-dimensional methods such as Computed Tomography (CT) and Cone beam CT (CBCT).

The advantages of panoramic radiography are availability, low cost, low radiation dose, extensive coverage of facial and teeth bones, short imaging time, and understandability of panoramic images for the patients [8]. The disadvantages of this method include superimposing anatomic structures, vertical and horizontal magnification (10%-33%), unavailability of faciolingual bone images, and the lack of cross-sectional data [9-11]. CBCT has overcome the limitations of panoramic radiography by producing multi-planar images without magnification. Although this method provides high-quality images, the effective radiation dose of CBCT devices can range between 10 and 1200 µSv depending on the device type. This amount of radiation is equivalent to 2 to 240 panoramic radiographies.

According to previous research, conventional periapical radiography cannot be used for predicting maxillary sinus perforation in periapical surgery. Advanced imaging techniques, such as CBCT are, hence, required in such cases [12]. CBCT imaging is also used in endodontic retreatment, trauma, temporal mandibular joint bone lesions and pathology, the assessment of vital facial structures (e.g. maxillary sinus), and tooth positioning in orthodontic treatments [13].

The biological structures of different populations have different genetic features that can justify their distinct anatomic and topographic relations. The anatomical knowledge of the structures that form the middle and lower parts of the face, especially the maxillary sinus and its relationship with posterior teeth, is essential for not only the careful diagnosis of the maxillary sinus and periapical inflammatory changes but also proper treatment, operation, and rehabilitation programs [6].

Clinicians performing implant surgery in the posterior maxilla should pay particular attention to the cases of root protrusion into sinus as they may entail a risk of pneumatization following tooth extraction and result in the reduced amount of available bone. The present study aimed at assessing the distance between posterior teeth and maxillary sinus floor, using CBCT in patients referring to a private oral and maxillofacial radiology clinic in Rafsanjan, Iran.

2. Materials and Methods

The present descriptive cross-sectional study evaluated 35 CBCT radiographs belonging to patients aged 20 years or older, who were referred to a private oral and maxillofacial radiology clinic in Rafsanjan, Iran, for dentistry procedures. Patients born and living in Rafsanjan were included if they had fully erupted posterior teeth, fully formed apex, and at least one maxillary posterior tooth. The exclusion criteria were external resorption, periodontal envelope, bone changes, maxillary sinus infection, operations involving sinuses and absence, or the extraction of mandibular molars (because of overgrown

Table 1. Frequency distribution of various types of distances between posterior teeth and maxillary sinus floor

Group Type	Frequency (%)											
	Left						Right					
	Second Molar			First Molar			Second Molar			First Molar		
	DB	P	MB	DB	P	MB	MB	P	DB	MB	P	DB
1	4 (16.7)	7 (28.2)	6 (25.0)	8 (50.0)	5 (31.3)	6 (37.5)	6 (37.5)	6 (37.5)	6 (37.5)	3 (15.8)	6 (31.6)	4 (21.1)
2	4 (16.7)	5 (20.8)	6 (25.0)	3 (18.8)	1 (6.3)	7 (43.8)	3 (18.8)	2 (12.5)	4 (25.0)	5 (26.3)	4 (21.1)	2 (10.5)
3	0	0	3 (12.5)	1 (6.3)	2 (12.5)	1 (6.3)	1 (6.3)	0	1 (6.3)	1 (5.3)	1 (5.3)	3 (15.8)
4	5 (20.8)	4 (16.7)	0	2 (12.5)	2 (12.5)	1 (6.3)	2 (12.2)	3 (18.8)	2 (12.5)	4 (21.1)	3 (15.8)	2 (10.5)

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maxillary molars). Moreover, patients with systemic diseases (e.g. hemolytic anemia and thalassemia) and bone lesions (benign and malignant tumors, cysts, and other bone lesions) in the maxillary sinus region, which affected sinus size and its interaction with the teeth, were excluded.

The CBCT imaging was performed, using Planmeca Promax and CBCT 3D Classic (Helsinki- Finland) and the current voltage-time was set at 12 mA to 14 mA, 82-84 kVp, and 12 s, respectively. After obtaining Multi-Planar Reformatted (MPR) images (produced by placing sagittal and coronal axes along the longitudinal root axis so that the tooth apex could be clearly observed) (Figure 1 A, B), a maxillofacial radiologist measured the vertical relationships (the shortest distance) among the mesiobuccal, distobuccal, and palatal roots of posterior maxillary teeth (except for wisdom tooth) and the maxillary sinus floor. All measurements were performed, using the Planmeca Romexis 3.8.3 software (Figure 2). The measured values were classified as described by Didilescu et al. [14]. Distances 0, 0-2, 2-4, 4-6, and >6 mm were classified as type 0 to 4, respectively. To assess the intraobserver agreement, 10% of the images were randomly selected 2 weeks later and reassessed by the same radiologist (with no knowledge of the initial measurements).

The collected data were analyzed by SPSS V. 21. The relationships among teeth region and morphological classification, age, and gender were determined, using the independent t-test, the paired t-test, and the non-parametric Kolmogorov-Smirnov test. P-values less than 0.05 were considered significant in all tests.

3. Results

A total of 73 teeth of 35 selected CBCT radiographs were evaluated. Of the 35 patients, 15 (42.9%) were women and 20 (57.1%) were men. The Mean±SD age of the patients was 20.38±9.42 years. In all samples of the left region, the distances among the maxillary sinus floor and mesiobuccal (37.5%), palatal (33.3%) and distobuccal (45.8%) roots of the posterior second molars were mostly type 0. In the first molars, the distance among the maxillary sinus floor and distobuccal, palatal, and mesiobuccal roots were mostly type 1, 0, and 2, respectively with prevalnece rate of 50%, 37.5%, and 43.8%, respectively (Table 1).

Moreover, in all samples of the right region, the distances between the maxillary sinus floor and mesiobuccal (31.6%) and distobuccal (42.1%) roots of the second molars were mostly type 0. The distance between the maxillary sinus floor and the palatal root of second molars was mainly type 1 (26.3%). In the first molars, the distance among the maxillary sinus floor and mesiobuccal, palatal, and distobuccal (37.5%) roots were mostly type 0 (Table 1).

As seen in Table 1, the distobuccal root of the second molars had the nearest distance from the maxillary sinus floor. Based on the studied CBCT images, the frequencies of type 0 to 4 were 30.2%, 29.7%, 20.4%, 6.2%, and 13.3%, respectively. Therefore, class 0 (distance=0 mm) was the most frequent.

The patients were divided into two groups according to their age (≤40 and >40 years). A total of 50 teeth belonged to the first group (≤40 years) and 40 teeth belonged to the second group (> 40 years). According to the results of the independent t-test, no significant differences were found between patients >40 years and ≤40 years in terms of the mean distance between posterior teeth and maxillary sinus floor in all studied first and second molars. The independent t-test also showed no significant differences in the mean distance between pos-

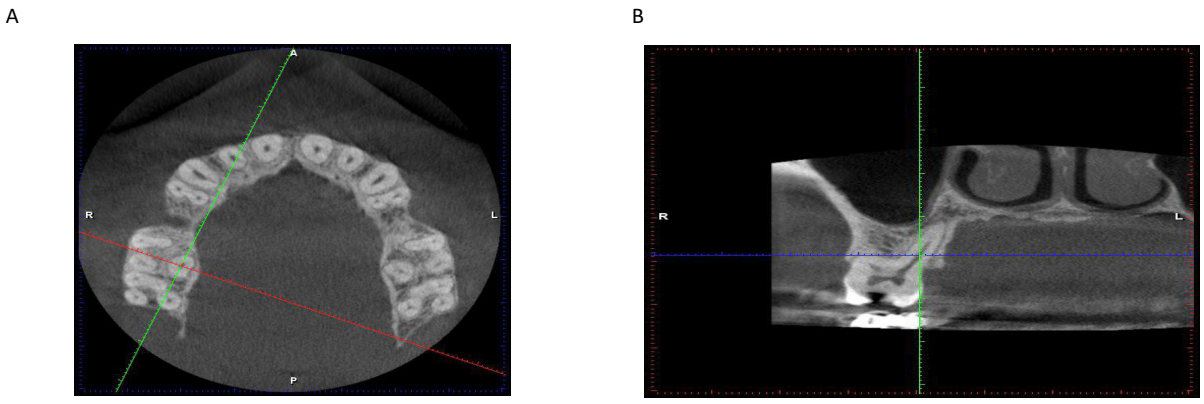

Figure 1. The method of providing MPR images

a. Axial view; b. Sagittal view

terior teeth roots and the maxillary sinus floor between men and women (except for the first molar palatal root in the left region, whose distance was significantly greater in women than in men). The paired t-test showed no significant differences between the left and right regions in terms of the mean distance between posterior teeth roots and the maxillary sinus floor.

4. Discussion

The anatomical knowledge of the maxillary sinus and its relationship with maxillary posterior teeth is highly important in not only surgical procedures, such as the extraction of maxillary posterior teeth, implantation, and sinus lifting but also understanding the development of pulpal diseases into the sinus and orthodontic movement (e.g. intrusion) of the maxillary posterior teeth. In half of the people, the maxillary sinus floor extends between the maxillary posterior teeth roots and causes the protrusion of the sinus floor or the tip of the roots into the sinus. The risk of pneumatization has been observed following tooth extraction in cases, where roots protrude into the sinus. This would reduce the available bone for dental implants or maxillary dentures [3].

Given the differences in genetic characteristics of different populations, this study used CBCT images to assess the relationship between maxillary posterior teeth and the maxillary sinus floor in the residents of Rafsanjan. The results showed that the distobuccal root of the second molar had the shortest distance from the maxillary sinus floor. This finding was in line with the results reported by Kiliey, Asthana, Kwak, and Kilic [7, 15-17]. However, it was in contrast with the findings of Didilescu et al. Jung, Poorebrahim, and Shokry [14, 18-20].

Didilescu et al. studied a population in Romania and found the palatal root of the first molar to have the shortest distance from the maxillary sinus floor [14]. These researchers only evaluated the first molars; thus, their results were different from those of the present study.

Figure 2. Measurement of the shortest distance from the root to the maxillary sinus

Jung et al. identified the mesiobuccal root of the second molar as the nearest to the maxillary sinus floor [18]. The difference between their findings and ours might be justified by the difference in sinus pneumatization in different ethnicities. Poorebrahim et al. reported the mesiobuccal root of the second molar to have the shortest distance from the maxillary sinus floor [19]. Differences in the measurement methods (CBCT images vs. coroner autopsy) might have been responsible for the different results of their study and ours.

Shokry et al. used Didilescu et al.'s classification and found that the palatal root of the first molar was the closest to the maxillary sinus floor [20]. The difference between their findings and ours might be because they only evaluated the first molars.

Based on the Didilescu et al.'s classification, the distance between the maxillary posterior teeth and the maxillary sinus floor in the population of Rafsanjan was mostly type 0. This is in agreement with the findings of Didilescu et al. but in contrast with the results obtained by Shokry, and Shubhasini [14, 20-23].

Shokry et al. used the same classification method but found type 1 as the most frequent in a population from Saudi Arabia [20]. The different ethnicities of the participants can justify the difference between their findings and ours. Shokri et al. identified type 3 (intrusion of roots into the sinus) as the most frequent type in Hamedan, Iran [21]. Discrepancies in growth patterns in different ethnicities might have caused the difference between their findings and ours. Shubhasini et al. used Didilescu classification and found type one as the most frequent type in a population in India [22]. Ethnicity and small sample size might have been responsible for the difference between the results of their study and ours.

The present study showed no significant difference between the right and left regions. Similar results were obtained by Kiliey, Kilic, and Shokri [15, 17, 21]. However, although Shokry et al. found no significant difference between the left and right regions, the left side had a closer relationship with the maxillary sinus floor [20]. The difference in the present study might have been because of the differences in the sinus growth pattern and its asymmetrical growth.

The present study showed no significant difference between men and women. This was in agreement with the results obtained by Kiliey, Kilic, and Shokry, but in contrast with those found by Shokri et al. who reported the protrusion of roots into the sinus as more common in men than in women [15, 17, 20, 21]. This difference between the two studies can be justified by the different shapes of the maxilla in men and women of different ethnicities.

The present study showed no significant difference between patients aged ≤40 and >40 years old. This was similar to the results obtained by Didilescu et al. but in contrast with the findings of Shubhasini and Arji [14, 22, 23]. Shubhasini et al. indicated that the distance was significantly greater in 40-49-year-old patients [22]. The difference between the results of their study and ours might have been caused by the difference in ethnicity and limitation in sample size. Arji et al. showed that the distance between posterior teeth and the maxillary sinus floor increased until 20 years of age, but decreased thereafter [23]. Sinus enlargement might have caused the difference between their findings and ours.

5. Conclusion

Given that the distance between maxillary posterior teeth and the maxillary sinus floor was mostly type 0 in the population of Rafsanjan, clinicians are recommended to use CBCT to acquire adequate knowledge of the root anatomy and its morphological details before any treatment, especially surgical procedures.

Ethical Considerations

Compliance with ethical guidelines

The study was conducted after receiving the Code of Ethics: IR.RUMS.REC.1395.149.

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Authors contribution's

Conceptualization, methodology: Zahra Tafakhori, Somayeh Nemati; Investigation, writing-original draft: Zahra Tafakhori; Writing-review & editing: Zahra Tafakhori, Mahmood Sheikhfathollahi, Resources and Supervision: All author.

Conflict of interest

The authors declared no conflict of interest.

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