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Location of the Maxillary Posterior Tooth Apices to the Sinus Floor in an Egyptian Subpopulation Using Cone-beam Computed Tomography

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ABSTRACT

Introduction: The aim of this study was to evaluate the location of the apices of the maxillary posterior teeth to the maxillary sinus floor (MSF), the symmetry between both sides and the possible variations between males and females using cone-beam computed tomography (CBCT) in an Egyptian subpopulation. **Materials and Methods**: CBCT images were collected from 120 patients (240 second premolars, 480 1st and 2nd molars, 1680 roots). The proximity of roots of maxillary second premolar and 1st and 2nd molars to the floor of the sinus was categorized into three categories: inside the sinus floor (IS), touching the sinus floor (TS) or outside the sinus floor (OS). The correlation of the distance with gender was analyzed as well as for symmetry. Friedman's test was used to compare between different roots and the Dunn's test was used for pair-wise comparisons when Friedman's test was significant. The Mann-Whitney U test was used to compare males and females. The significance level was set at $P \leq 0.05$. **Results**: The highest prevalence of roots outside the sinus was found with second premolar (right and left) followed by palatal roots of right and left second molar. In addition, the highest prevalence of roots inside the sinus was found with mesiobuccal roots of maxillary second molar followed by the palatal root of maxillary first molar. There was no statistically significant difference between males and females or between both sides. **Conclusion**: Neither gender nor side variations regarding the proximity to the maxillary sinus floor were observed.

Keywords: Cone-beam Computed Tomography; Maxillary Sinus Floor; Tooth Apices

Introduction

The maxillary sinus (MS) is a crucial anatomical landmark nearby the nasal cavity and adjacent to the root apices of the maxillary posterior teeth. The maxillary sinus floor (MSF) is developed by the maxillary alveolar process and found at 5 mm inferior to the nasal floor almost at 20 years old [1]. Intrusion of posterior teeth roots into the maxillary sinus has various clinical consequences. If the root is in close proximity or extended into the MSF, there is a great liability of perforation of the floor during tooth extraction. As a result, oroantral fistula could be formed [2]. Maxillary sinusitis could be created because of the periapical and marginal lesions of roots near to or protruding into the MSF which produce inflammatory changes of the sinus lining mucosa [3]. Additionally, infection could spread into the sinus through bone marrow, blood vessels and lymphatics. Mehra and Murad [4] demonstrated that when there was a close contact of root apices of teeth with necrotic pulp and the MSF, the MS might also be affected. Iatrogenic mishaps during root canal treatment such as over-instrumentation, extruded fracture instrument, extruded irrigants or filling materials can lead to serious complications in the MS. Dentists and otolaryngologists are facing serious problems because of dental causes such as: odontogenic maxillary sinusitis, endo-antral syndrome and traumatic alterations [5, 6]. Cone-beam computed tomography (CBCT) is an accurate, non-invasive method to evaluate the relation of the apices of the

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Figure 1. Representative CBCT images of the 3 types of relationships between maxillary posterior roots' apices and MSF in coronal planes showing; *A*) Type TS (positive value, the root apex is touching the MSF) with the white arrow; *B)* The red arrow shows the type IS (negative value, the root apex inside the MSF), while the yellow arrow shows the Type OS (Positive value, the root apex is outside the MSF); MSF: maxillary sinus floor

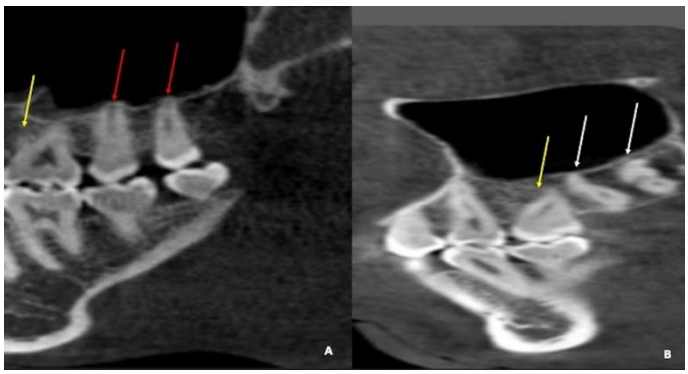

Figure 2. Representative CBCT images of the 3 types of relationships between maxillary posterior roots' apices and MSF in sagittal planes in *A* and *B* showing: Type TS (positive value, the root apex is touching the maxillary sinus floor) with the white arrows, Type IS (negative value, the root apex inside the MSF) with the red arrows, and Type OS (Positive value the root apex inside the MSF) with the yellow arrows

Figure 3. Representative CBCT scan showing *A*) Sagittal view; *B*) Coronal view illustrating measurement of the root apex to the maxillary sinus floor; *C*) Axial view; *D*) 3D reconstruction

maxillary posterior teeth to the MSF [7]. Up to our knowledge, one published study was conducted in Egypt investigated the proximity of the MSF to the roots of the posterior molars and they used Jung's classification [8, 9]. Hence, the aim of this study was to assess the relationship of the root apices of the maxillary posterior teeth including maxillary second premolars to the MSF using Kilic's classification [10], the symmetry between both sides and the possible variations between males and females using CBCT in an Egyptian subpopulation in Ismailia.

Materials and Methods

The current retrospective study was started after the agreement of the Research Ethics Committee (REC), Faculty of Dentistry, Suez Canal University, Ismailia, Egypt (Registration No. 328/2021). CBCT scans of maxillary second premolars and 1st and 2nd molars for 120 patients, (240 second premolars, 480 molars, 1680 roots), were taken from January 2018 to June 2019 and collected from the Oral Radiology Department at the College of Dentistry.

The scans were selected from the archive taken for diagnostic purposes irrelevant to the present study. The scans were obtained by the oral radiologist who assessed in the present study. The Inclusion criteria were: *1*) patients who had maxillary second premolars and 1st and 2nd molars on both sides with fully closed apices, *2*) patients' age ranging between 20 to 25 years. Exclusion criteria were: *1*) more than one maxillary posterior or anterior tooth lost in each side except for third molar, *2*) severe periodontitis, *3*) external or internal root resorption of any maxillary tooth in the examined area, *4*) existence of a lesion in the examined area, *5*) past history of an orthodontic treatment, *6*) skeletal or dental malocclusions, *7*) unusual root anatomy, *8*) any diseases in the MS, and *9*) former endodontic treatment in the examined area.

All CBCT images were acquired using a SCANORA 3DX scanner (Scanora 3DX, Soredex, Finland). The field of view was fixed at 240×165 mm for all images using standard resolution mode. The operating parameters were 90 kVp, 10 mA and the scan time was about 6 sec. The isotropic voxel size was 0.5 mm using amorphous-silicon (a-Si) flat panel detector. The acquired data was transferred into digital imaging and communications in medicine (DICOM) format, then exported into On Demand 3D application software (On Demand Cybermed. Co., Seoul, Korea) for image analysis and measurements that were used to evaluate the maxillary second premolars and 1st and 2nd molars and the nearby anatomy.

The CBCT scans were assessed by an oral radiologist and two endodontists who were guided by the oral radiologist. The examiners were adjusted for radiographic interpretation of the scans where each one of them repeated the assessment 2 times

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within a week to check the intra-examiner reliability. Additionally, comparing the three examiners' readings showed the reliability between them, and a mean was taken. Any conflict about measurements gave rise to a discussion that led at the end to an agreement (inter-examiner reliability). The examiners got the capability to modify the images for better interpretation.

The proximity of the maxillary posterior roots' apices to the MSF were investigated from a 3D module as well as a dynamic light box module in CBCT from sagittal and coronal planes concurrently and classified into 3 types: *1.* Type (IS): the root apex inside the MSF, *2.* Type (TS): the root apex is touching the MSF and *3.* Type (OS): the root apex is outside the MSF [11] (Figures 1, 2). Consecutive sagittal and coronal planes of 0.2 mm slice thickness were verified so that the nearest margin of the MSF was calculated. A negative value was measured if the root apex is insider the MSF.

Using 3D module, the maxillary sinus was located, cross-sectional slices from the 3D view mode was conducted to finish all the measurements at the radiographic apex of each maxillary molar root. CBCT slices were registered in a resolution range between 0.2 mm-0.3 mm. Measurements were also taken from coronal cuts of the dynamic light box module to confirm the measurements in the cross-sectional cut of the 3D module (Figure 3).

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed non-normal (non-parametric) distribution. Data were presented as median, range, mean and standard deviation (SD) value. Friedman's test was used to compare between the different roots. Dunn's test was used for pair-wise comparisons when Friedman's test was significant. Mann-Whitney U test was used to compare between males and females. Qualitative data were presented as frequencies and percentages. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS statistics software for Windows, (SPSS version 23.0, IBM Corp., Armonk, NY, USA).

Results

The present study was conducted on 120 subjects: 62 females (51.7%) and 58 males (48.3%) with a mean of age 22.4 years ranging between 20-25 years. Seven hundred and twenty premolars and molars met the inclusion criteria (120 for maxillary right 2nd premolar, 120 for maxillary left 2nd premolar, 240 for the maxillary 1st and 240 for the maxillary 2nd molars). One thousand six hundred and eighty roots were examined for the current study.

The frequency of the distance between the maxillary posterior root apices and the MSF

As shown in Table 1, Type OS was the most common frequent of all root apices to the MSF and it was the highest in the maxillary 2nd premolars (MSPs) ($P<0.05$). Type IS was highest in the mesiobuccal roots of the maxillary second molars (MSMs) and the palatal roots of the maxillary first molars (MFMs) (45.8% and 39.2%, respectively). There were no significant differences between males and females in all posterior roots ($P>0.05$). There was no significant difference between the two sides as well ($P>0.05$).

Table 1. Frequencies (n), percentages (%) and results of Friedman's test for comparisons between positions of different roots in relation to the maxillary sinus (*: Significant at $P \leq 0.05$)

Tooth and Root	Outside sinus		Touching sinus		Inside sinus	
	N	%	N	%	N	%
Right second premolar	83	69.2	20	16.7	17	14.2
Left second premolar	84	70	20	16.7	16	13.3
Right first molar (Palatal root)	57	47.5	17	14.2	46	38.3
Left first molar (Palatal root)	55	45.8	18	15	47	39.2
Right first molar (MB root)	60	50	24	20	36	30
Left first molar (MB root)	59	49.2	26	21.7	35	29.2
Right first molar (DB root)	57	47.5	28	23.3	35	29.2
Left first molar (DB root)	60	50	23	19.2	37	30.8
Right second molar (Palatal root)	71	59.2	22	18.3	27	22.5
Left second molar (Palatal root)	71	59.2	21	17.5	28	23.3
Right second molar (MB root)	44	36.7	28	23.3	48	40
Left second molar (MB root)	40	33.3	25	20.8	55	45.8
Right second molar (DB root)	62	51.7	26	21.7	32	26.7
Left second molar (DB root)	64	53.3	24	20	32	26.7
***P*-value**	<0.001*					
Effect size (*w*)	0.106					

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The mean distances between the maxillary posterior root apices and the MSF

There were no significant differences between right and left side maxillary posterior root apices of the distances (P>0.05). The MSPs had the largest distances, followed by the palatal roots (PRs) of the maxillary second molars then the distobuccal roots of the maxillary first molars (P<0.05), while the mesiobuccal roots (MBRs) of the MSMs had the lowest distances for both males and females (Table 2).

Comparison between males and females

Regarding all teeth and roots, there was no statistically significant difference between distance between roots and maxillary sinus in males and females (Table 3).

Discussion

The proximity of the maxillary posterior root apices to the MSF may result in several problems during dental procedures. That is why the radiographic assessment of the close relationship of the maxillary posterior teeth to the MSF before either conventional or surgical endodontics is mandatory [3]. To exclude the age as factor, because it is already known the proximity of the maxillary posterior root apices to the MSF varies with age [11, 12], the CBCT scans were collected and unified to one age group (20-25 years.). We did not examine the maxillary 1st premolar because it is well documented its farther distance to the MS [13, 14]. Maxillary 3rd molar was not included in the study as it is rarely treated either surgical or non-surgical.

Table 2. Descriptive statistics and results of Friedman's test for comparisons between different roots' distances from the maxillary sinus; Min: minimum, Max: Maximum, SD: standard deviation

Tooth and Root	Median	Min	Max	Mean (SD)	*P*-value	Effect size (w)
Right second premolar	2.2 ^{A}	-3.5	13.8	2.72 (3.24)	<0.001*	0.173
Left second premolar	2.1 ^{A}	-3.3	16.3	2.83 (3.3)		
Right first molar (Palatal root)	0.85 ^{C}	-5.5	7.8	0.44 (2.7)		
Left first molar (Palatal root)	0.8 ^{C}	-5.2	12	0.62 (2.8)		
Right first molar (MB root)	0.95 ^{C}	-7.7	12	1.12 (3.07)		
Left first molar (MB root)	0.9 ^{C}	-8.7	13.9	1.09 (3)		
Right first molar (DB root)	0.9 ^{C}	-4.9	12.5	0.81 (2.6)		
Left first molar (DB root)	0.95 ^{C}	-5	10.9	0.94 (2.57)		
Right second molar (Palatal root)	1.25 ^{B}	-3.9	9.4	1.23 (2.29)		
Left second molar (Palatal root)	1.2 ^{B}	-4	8.2	1.42 (2.38)		
Right second molar (MB root)	0.55 ^{D}	-5.8	10.4	0.32 (2.23)		
Left second molar (MB root)	0.45 ^{D}	-5.8	7	0.06 (2.22)		
Right second molar (DB root)	1 ^{C}	-5	11.2	1.13 (2.62)		
Left second molar (DB root)	1.05 ^{C}	-4.40	7.9	1.16 (2.33)		

** Significant at P≤0.05, Different superscripts indicate statistically significant difference between roots*

Table 3. Descriptive statistics and results of Mann-Whitney U test for comparisons between different roots' distances from the maxillary sinus in males and females; Min: minimum, Max: Maximum

Tooth and Root	Males			Females			*P*-value	Effect size *(d)*
	Median	Min	Max	Median	Min	Max		
Right second premolar	2.25	-3.5	10.3	2.15	-3.5	13.8	0.992	0.002
Left second premolar	1.75	-2	16.3	2.35	-3.3	11.5	0.733	0.062
Right first molar (Palatal root)	0.6	-4.3	7.8	1	-5.5	6.5	0.258	0.208
Left first molar (Palatal root)	0.5	-5.2	12	0.95	-4.5	6	0.277	0.199
Right first molar (MB root)	0.85	-7.7	12	1.15	-6	10.1	0.483	0.128
Left first molar (MB root)	0.7	-8.7	13.9	1.05	-4.1	8	0.867	0.031
Right first molar (DB root)	0.8	-4.8	12.5	0.9	-4.9	7.8	0.914	0.02
Left first molar (DB root)	0.95	-5	10.9	0.95	-2.8	6.1	0.998	0
Right second molar (Palatal root)	1.1	-3.8	9.4	1.4	-3.9	5.9	0.383	0.16
Left second molar (Palatal root)	1.05	-4	8.2	1.25	-2.1	5.7	0.692	0.072
Right second molar (MB root)	0.4	-5.8	10.4	0.75	-2.4	7.1	0.359	0.168
Left second molar (MB root)	0.4	-5.8	6.9	0.6	-3.3	7	0.421	0.147
Right second molar (DB root)	0.75	-5	11.2	1.3	-4	8.6	0.089	0.314
Left second molar (DB root)	0.8	-4.4	7.9	1.1	-3.4	7.6	0.475	0.131

**: Significant at P≤0.05*

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In the current study, the proximity of the maxillary posterior root apices to the MSF in an Egyptian subpopulation was studied. A recent study examined the proximity of the 3 maxillary molars' roots to the MSF where they used Jung's classification and they did not examine the 2nd premolar [9]. In the present study, Kilic's classification has been adopted and that was followed in many studies [10, 11, 15, 16]. The results showed that the Type OS (the root apex is outside the MSF) was observed in 70% of MSPs, which is in accordance with the former research [10, 12, 17] demonstrating that the roots of MSPs have slight proximity with the MSF. No statistically significant differences were observed between the left and right MSPs, which is in consistency with the results of previous studies [10, 12, 15].

For maxillary 1st and 2nd molars, results showed the highest frequency of Type IS in the MBRs of the MSMs and the palatal roots of the MFMs (45.8% and 39.2%, respectively), this is like an alarm to the endodontists to be cautious during root canal treatment to prevent extrusion of either root canal materials or the surgical endodontics of upper molars. This observation was in concurrence with earlier studies [12, 14, 16, 18]. Nevertheless, other studies showed different results which emphasize the ethnic difference that should be kept in consideration. Brazilian study registered Type IS in the MBRs, DBRs and PRs of the MFMs were 3.2%, 1.8% and 5.5%, respectively [17]. Additionally, they reported Type IS in the MBRs, DBRs and PRs of the MSMs were 12.9%, 8.3% and 4.1%, respectively [17]. Type IS has been recorded in the Korean population in the MBRs and DBRs of the MFMs where the frequency was 32.5% and 30.1% respectively [19]. Moreover, they revealed Type IS in MBRs and DBRs of MSMs where the frequency was and 36.7% and 34.3%, respectively [19]. Similarly, a Turkish study disclosed Type IS in 34.2% for MBRs of MFMs and 30.9% for MBRs and DBRs of MSMs [15].

The current results exhibited that the farthest distance to the MSF was related to the roots' apices of MSPs (2.83±3.3 mm), which were in agreement with the Turkish and Brazilian studies [10, 17]. That is of a paramount importance when treating maxillary molars especially 2nd molars, where the apices of the roots are in close proximity to the MS than those of the MSPs, so it is wise to anticipate diseases of the MS related to odontogenic reasons associated with the maxillary molars more than with MSPs [20]. Alternatively, the shortest distance to the MSF was related to the MBRs of MSMs (0.06±2.22 mm), followed by the palatal roots of the MFMs (0.44±2.7 mm) which was in concurrence with the two Chinese and one Romanian studies using CBCT [11, 16, 20]. On the other hand, a Japanese work expressed that the minimum distance to the MSF was for the PRs of the MFMs (1.67±2.36 mm) [21]. Interestingly, Turkish and Korean researchers reported that the minimum distance to the MSF was detected in the DBRs of the MFMs (0.25±2.17 and 2.74±3.23 mm respectively) [10, 22]. A recent Saudi study revealed that the minimum distance to the MSF was detected in the DBRs of the MSMs (0.68±0.39 mm) [23]. Various populations and different assessment methods may affect the results of the relationship of the maxillary posterior roots' apices to the MSF.

Comparing females to males there were no statistically significance results which are in agreement with previous studies [12, 23]. In contrary to other former researchers who found that males' CBCT measurements displayed higher prevalence of intruded apices in the MS [2, 9]. Although the study was conducted in Egypt, there are some discrepancies between it and a previous recent one done in Egypt as well [9]. In the current study, 39.2% of palatal roots of the MFMs were presented by Type IS, whereas Anter *et al.* [9] found that all MFMs included in the study were away from the MSF.

Conclusions

Within the limitations of the present retrospective study, which is the small population in a single area in Egypt, the second premolar was always at a distant of the MS and the second molar mesiobuccal root was closer to the maxillary sinus floor. The 2nd molar mesiobuccal root and the 1st molar palatal canal were more frequent inside the MS. Further investigation is needed to include more sample of Egyptian population in different regions of the country.

Conflict of Interest: 'None declared'.

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