



ORIGINAL ARTICLE

Radiographic evaluation of the anatomical relationship of maxillary sinus floor with maxillary posterior teeth apices in the population of Al-Qassim, Saudi Arabia, using cone beam computed tomography

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Abstract *Background & objective:* In current clinical dental practice radiographic imaging plays a major role in exploring the relationship between the maxillary sinus floor (MSF) and maxillary posterior teeth root apices, especially when there is an involvement of pathology in the periapical area that may lead to infectious, inflammatory or traumatic changes in the maxillary sinus (MS). It is also essential for exact implant placement, and therapeutic and surgical plans. The prevalence of different forms of anatomic relationship of the MSF to posterior root apices from one population to another is large. Hence the current research was conceived to evaluate the horizontal and vertical relationship forms of posterior root apices to the MSF in the Al-Qassim population of Saudi Arabia using Cone Beam Computed Tomography (CBCT).

Materials and methods: To conduct the study, a total of 200 patients' data (100 male and 100 female) were taken from the archives. The linear distances of the root apices to the MSF were measured for maxillary posterior teeth. On cross-sectional CBCT images, the Kwak et al. criteria were used to assess the horizontal and vertical relationships between the root apices of maxillary posterior teeth and the MSF.

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Results: The mean distance between the apices of the maxillary second premolar ranged from 4.63 mm to 6.49 mm. The mean value of the distance between the apices of the posterior teeth and the MSF had a range of 0.68 ± 0.39 mm on the disto-buccal root (DBR) of the maxillary right second molar to 3.93 ± 1.26 mm on the palatal root (PR) of the maxillary left first molar. A similar result was observed in the maxillary second molar DBR in the male group (0.68 ± 1.17 mm) and the female group (0.69 ± 1.17 mm). The most frequently observed vertical relations were type 2 and type 2H horizontal relations.

Conclusion: This study concludes that maxillary molar roots show greater proximity with the MSF when compared with premolars, and that the type 2 vertical and type 2H horizontal distribution suggests that the anatomy of each tooth and the maxillary sinus floor should be evaluated by CBCT prior to treatment planning.

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1. Introduction

In the human body the first, and largest, sinus to develop is the MS. The growth of this sinus begins in the intrauterine period of life, and reaches its maximum size and forms the shape of a pyramid by the time of the third molar eruption or at the age of approximately 21 years. The floor of the MS is formed by the alveolar and palatine process of the maxilla and is lined by a thin mucosal membrane over the cortical bone (Kilic et al., 2010). The close proximity and relation of the vital structures to the teeth apices may defer or delay dental procedures, and makes the spread of infection more likely. As a result, radiographic anatomical examinations that determine the proximity of the maxillary posterior teeth root apices to the MSF contribute to prompt diagnosis, delivering the best dental treatment options, and reaching treatment goals. It also a known fact that the presence of periapical pathology or active periodontal infections may contribute to MS infections or traumatic alterations in the MSF (Haumman et al., 2002; Nair et al., 2010; Maillet et al., 2011). However, the spread of disease from the periapical area to the MS is still not clearly explained in the literature (Estrela et al., 2014).

Detailed study of the proximity of the maxillary posterior teeth root apices to the MSF is a mandatory step before endodontic procedures to avoid over-instrumentation or over-filling of restorative materials, as this may result in pushing foreign material into the MS, resulting in the spread of infection if not identified by radiographic imaging (Obayashi et al., 2004). The use of CBCT to assess the presence and possible spread of infection from the periapical area to the MSF achieved prompt radiological diagnosis that allowed superior treatment options and resulted in avoiding possible complications (Maloney et al., 1968; Brook et al., 2006; Oberli et al., 2007; Estrela et al., 2008; Nunes et al., 2016). Most 3-D radiography studies involving the maxillofacial region revealed that apical protrusion of the maxillary root apices into the MS, with a significant variation in anatomy, occurred between populations. It is also reported in a histopathological study that in a few cases, the floor of the MS is only covered by mucous membrane, without significant cortical bone (Shahbazian et al., 2010). Apical protrusion of the posterior root apices into the MSF has significant clinical importance because an attempt to extract the roots or an extensive periapical surgical procedure can create oro-antral communication or result in the entry of the root into the MS. We encounter a large number of

procedures in daily dental practice involving these areas. These include extractions, extensive surgical implant procedures involving maxillary sinus lift operations in immediate implant surgery and maxillary sinus floor augmentation procedures hoping for the osteogenesis to accommodate and support the future implant. The variation in the relationship of root apices with respect to the MSF may result in disaster if we do not consider the actual radiographic anatomy of apical projection over the MSF and the thickness of the cortical bone over the root apices.

Considering the distinct anatomical features in different populations, and variations within an individual between different maxillary molars, this research was conducted to find the proximity of the MSF to the maxillary posterior root apices, and to ascertain the prevalence of different forms of vertical and horizontal relationships between the maxillary posterior teeth root apices and the MSF in a population from Al Qassim, Saudi Arabia, using cone-beam computed tomography (CBCT).

2. Materials and methods

2.1. Ethical clearance

Ethical clearance was obtained from the Qassim University ethical committee with the order ST/56/2019, and the cases were selected by the ethical committee of the college of dentistry research center as per the guidelines of the Helsinki Declaration of 1975.

2.2. Sample selection

The study was carried out in maxillofacial radiology clinics, using existing data from departmental CBCT archives (Sirona Dental Systems GmbH, Bensheim, Hessen, Germany, used with Sidexis-XG software). In this research 200 samples (100 male and 100 female), from patients aged between 21 and 50, were selected.

2.3. Eligibility criteria

CBCT images of patients with full sets of dentition, without any maxillofacial disease, were included in the study. Patients with congenital anomalies in the maxillary sinus, maxillary

sinus polyps, maxillary sinusitis, prosthetic restorations, root-canal treatments, TMJ disorders, and orthodontic treatments, were excluded.

2.4. CBCT analysis

Using Sidexis-XG software, the distance from the maxillary sinus floor to the maxillary posterior teeth apices on both the right and left sides were measured on cross-sectional CBCT images (Fig. 1). We evaluated a total of 800 first and second molar teeth on both the right and left sides, with maxillary first and second molars root apices to the floor of maxillary sinus, using cross-sectional images, and classified them into five types of vertical relationships according to Kwak et al., (2004). These were: Type I: floor of the maxillary sinus far superior to apices of buccal and palatal root; Type II: floor of the maxillary sinus located inferior to the apices of buccal and palatal roots, absence of apical protrusion above the maxillary sinus floor; Type III: presence of apical protrusion of buccal root apex into the maxillary sinus floor; Type IV: presence of apical protrusion of palatal root apex into the maxillary sinus floor; Type V: presence of apical protrusions of both buccal and palatal root apices above the floor of maxillary sinus (Fig. 2). The horizontal relationship between the floor of the maxillary sinus to the maxillary molar root apices was analyzed using CBCT cross-sectional images and categorized into five types as proposed by Kwak et al. (2004) – Type 1H: root apices with the alveolar recess of the floor of the maxillary sinus placed more towards the buccal side with respect to the buccal root; Type 2H: the alveolar recess of the floor of maxillary sinus is placed between the buccal and palatal roots; Type 3H: the alveolar recess of the maxillary sinus floor is placed more towards the palatal side with respect to the palatal root; Type 4H: the alveolar recess of the maxillary sinus floor crosses over the roots without establishing a relationship with them; Type 5H: the alveolar recess of the floor of the maxillary

sinus is towards the buccal and the palatal side, and may or may not extend between the roots.

2.5. Statistical analysis

Statistical analysis was performed to obtain the standard deviation and mean of the distances between the floor of the maxillary sinus and root apices, and the Kruskal-Wallis test was used to determine the distance differences. The chi-squared test was used for vertical and horizontal relationship form analysis. All statistical analysis was carried out using SPSS v.22.

3. Results

Our research found that the mean value of the linear distance from the MSF to the root apices ranged from 0.68 ± 0.39 mm on the DBR of the maxillary second molar to 3.93 ± 1.26 mm as compared with the maxillary first-molar PR. A close relationship was observed (Table 1) between the maxillary second molar DBR in the male group (0.68 ± 1.17 mm) and the female group (0.69 ± 1.17 mm). We also observed that the vertical relationship of Type 2 (29–70%) and the horizontal relationship of type 2H (28–67%) were found in our community at high frequency. There was no significant correlation when we compared the male and female groups. The second highest frequencies observed in our group were vertical type I (18–49%) and Type 4H (13–32%) horizontal relationships (Tables 2 and 3).

4. Discussion

With the introduction of CBCT into dental practice, linear measurement has become more acceptable and clinically accurate, and it is now widely used to evaluate the proximity of vital structures such as the inferior alveolar canal and maxil-



Fig. 1 A: Cross-sectional images showing maxillary second premolar with measurements (mm) of the distance between the root apex and maxillary sinus floor. Fig. 1, B-D: Cross-sectional images of maxillary molars with measurements (mm) of the distance between the root apices to the maxillary sinus floor.

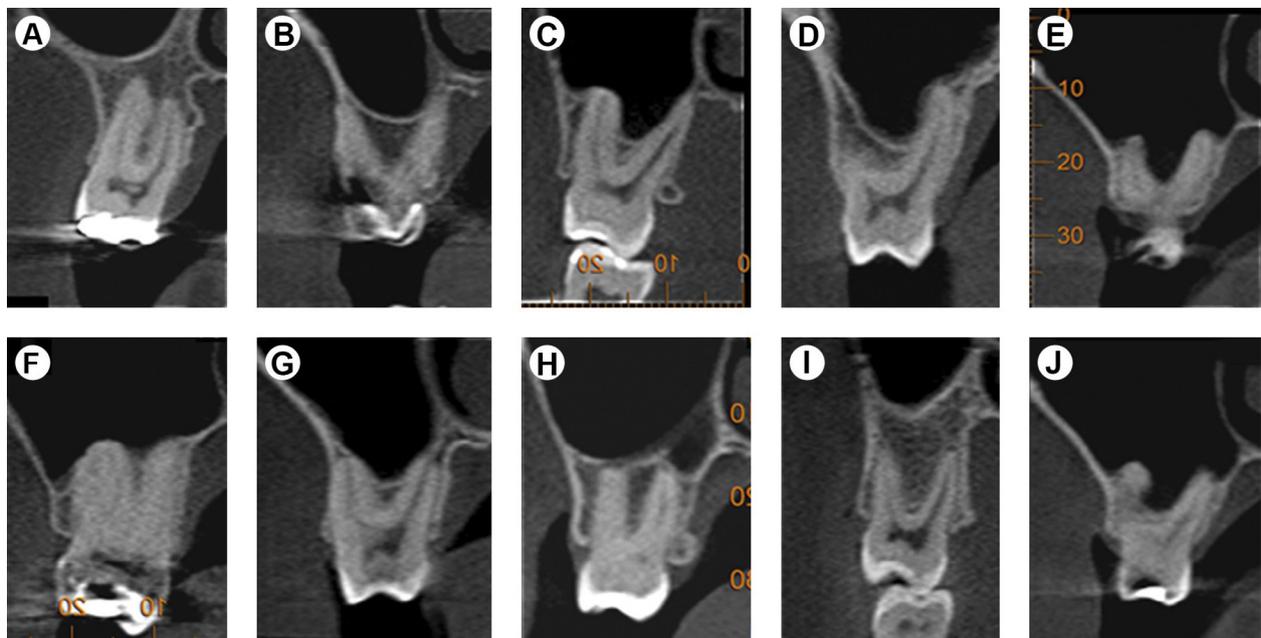


Fig. 2 A-E: Cross-sectional images showing vertical relationship from type I to type V, and F-J showing horizontal relationship from Type 1H to Type 5H.

Table 1 The mean distance and value of standard deviation (in mm) obtained between the maxillary sinus floor and posterior root apices.

Tooth Number	Gender	N	Mean	t-value	p-value
15	Male	100	6.4900	0.592	0.034
	Female	100	6.3904		
16 MBR	Male	100	2.1606	0.592	0.899
	Female	100	2.1703		
16 DBR	Male	100	2.0088	0.960	0.869
	Female	100	1.9935		
16 PR	Male	100	3.9344	0.960	0.277
	female	100	4.0141		
17 MBR	Male	100	0.7962	0.927	0.093
	Female	100	0.8653		
17 DBR	Male	100	0.6804	0.927	0.862
	Female	100	0.6952		
17 PR	Male	100	3.0232	0.647	0.322
	Female	100	3.2092		
25	Male	100	4.6746	0.647	0.427
	Female	100	4.6369		
26 MBR	Male	100	2.0130	0.293	0.847
	Female	100	1.9766		
26 DBR	Male	100	1.9324	0.293	0.14130
	Female	100	1.7911		
26 PR	Male	100	3.8924	0.786	0.05410
	Female	100	3.8383		
27 MBR	Male	100	1.2134	0.786	0.06660
	Female	100	1.2800		
27 DBR	Male	100	1.0828	0.347	0.02850
	Female	100	1.1113		
27 PR	Male	100	2.7312	0.347	0.15770
	Female	100	2.8889		

Table 2 Assessing the horizontal relationship between MSF and maxillary molar roots apices.

Tooth No	Gender	Type 1H	Type 2H	Type 3H	Type 4H	Type 5H	p- value
17	Male	10(10.0%)	28(28.0%)	17(17%)	32(32%)	13(13%)	0.326
	Female	6(6%)	33(33%)	22(22%)	33(33%)	6(6%)	
16	Male	6(6%)	57(57%)	2(2%)	31(31%)	4(4%)	0.148
	Female	3(3%)	65(65%)	7(7%)	20(20%)	5(5%)	
26	Male	6(6%)	57(57%)	11(11%)	24(24%)	2(2%)	0.334
	Female	3(3%)	67(67%)	14(14%)	15(15%)	1(1%)	
27	Male	12(12%)	50(50%)	18(18%)	18(18%)	2(2%)	0.001
	Female	34(34%)	29(29%)	23(23%)	13(13%)	1(1%)	

Table 3 Assessing the frequency of vertical relationship between the MSF and maxillary molar root apices.

Tooth Number	Gender	Type1	Type 2	Type 3	Type 4	Type 5	p- value
17	Male	18(18%)	50(50%)	18(18%)	4(4%)	0(0%)	0.084
	Female	28(28%)	56(56%)	9(9%)	3(3%)	0(0%)	
16	Male	32(32%)	62(62%)	2(2%)	0(0%)	4(0%)	0.045
	Female	49(49%)	46(46%)	0(0%)	0(0%)	5(5%)	
26	Male	22(22%)	64(64%)	8(8%)	6(6%)	0(0%)	0.409
	Female	18(18%)	70(70%)	10(10%)	2(2%)	0(0%)	
27	Male	18(18%)	48(48%)	18(18%)	12(12%)	4(4%)	0.054
	Female	32(32%)	29(29%)	18(18%)	16(16%)	5(5%)	

lary sinus in surgical planning and implant dentistry. It was hidden truth when practicing with the help of 2-D radiographic methods like periapical and panoramic radiography. In the present study, we obtained the measurement between the MSF and the root apices of the posterior teeth, and, when analysed, we observed that the molar roots apices are closer to floor of the MS when compared with premolars, and the apices of the DBR of the maxillary right second molar was nearest to the MSF. Hence, this study was in accordance with the observations seen in other population studies (Kwak et al., 2004, and Kilic et al., 2010). However, it differs from observations by others that the mesio-buccal root (MBR) of the second molar was the nearest root apex to the MSF (Eberhardt et al., 1992, Jung & Cho, 2012, Pagin et al., 2013). These variations in linear measurements and close proximity to the MSF when compared with different populations strongly suggest that CBCT cross-sectional radiographic studies in three different planes will help us obtain the actual radiographic location of the root apices and the MSF. It has been reported that patients presenting with evidence of apical periodontitis in relation to the maxillary first molar PR and the MBR of the second molar have a high frequency of maxillary sinusitis (Maillet et al., 2011). Again, these studies support the extensive use of CBCT to examine the presence and extent of periapical lesions in maxillary posterior teeth, which may not be seen in 2-D periapical or panoramic radiographs.

When we analysed 800 teeth (400 male and 400 female), we examined in detail the first and second molars on both the right and left sides for the frequency of each type of horizontal and vertical relationship. All of the first and second molars were categorized into vertical and horizontal relationships with

the MSF. We found the Type II vertical relationship to be the most common in our population (62–70%). But Kwak et al., 2004, found that the Type I vertical relation was most common in the Korean population. Similarly, Kilic et al., 2010, found that the Type I vertical relation was most common in the Turkish population. This could be due to major anatomical differences and variation in the diverse populations analyzed. A prevalence of Type I vertical relation without protrusion of roots into the sinus has been reported in other studies (Eberhardt et al., 1992; Sharan et al., 2006; Pagin et al., 2013). However, according to Jung and Cho, 2012, protrusion of the roots into the MSF is commonly encountered with vertical relation in their studied population. It has been reported that the protruded root showed very thin cortical bone covering when compared with Type I relation without apical protrusion into the MS (Wehrbein and Diedrich, 1992).

One study indicates that in 65.7% of cases involving periapical infections, alveolar cortical bone alterations were observed in maxillary teeth (Obayashi et al., 2004), and that the buccal cortical plate was more frequently affected. Furthermore, depending on the type of the horizontal relationship, a high frequency of alterations in the MS may be likely in situations with extensions towards the palatal and buccal sides (Types 1H, 3H, 5H), as it is easy to spread infection from the periapical area because of the close proximity and reduced thickness of the cortical bone covering it. The most frequently observed horizontal relationship of maxillary molar teeth with the MSF in the current study population was the 2H type relationship (28–67%). These data are in agreement with previous studies (Kwak et al., 2004; Jung & Cho, 2012). The second highest prevalence seen in our study was the Type 4H relation-

ship, in accordance with Jung and Cho, 2012, but in contrast with the study of Kwak et al., 2004. The third most common horizontal relationship noted in this population was type 1H, followed by type 5H. The high incidence of vertical Type II and horizontal Type 2H relationship forms in our group may favor better treatment outcomes. But we noticed that the second most common form of vertical type relationship was Type I, followed by Type III, suggesting detailed analysis of each tooth. In recent dental implant practice it has become a common trend to perform a sinus floor augmentation procedure, hoping to increase the amount of alveolar bone to withstand the future implant (multi-stage) and the sinus-lift procedure with the immediate implant (single stage); these depend on the amount of apical protrusion of the root apex into the MSF, and the thickness of the cortical bone. Radiographic evidence of periapical lesions in Type III and Type 4 vertical forms may be a threat for endodontic treatment. Because of the highly variable distributions of vertical and horizontal relationships in our study group, CBCT analysis is recommended. A limitation of our study was that we obtained CBCT images of ideal patients, in that we only used images that had been exposed already and did not expose any new cases for CBCT radiation for this study, based on ALARA regulations.

5. Conclusion

From the data obtained in our study, we conclude that the maxillary molar roots have a greater proximity to the MS when compared with the premolar. The most common vertical and horizontal relationships in the present population were type 2 and 2H, respectively. The significant difference in the frequency of vertical and horizontal relationships, between both the population and between individuals, strongly suggests that a CBCT examination of maxillary posterior teeth and their proximity with the maxillary sinus should be carried out before diagnosis and treatment planning, which may also help to rule out the periapical pathologies and guide the selection of bone graft and type of sinus lift procedures.

Recommendation

Since the sample size involved in our research was small, we recommend in-depth research into this area with a larger study group and involving different populations in future.

Ethical considerations

The present study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), 1975. It was approved by the Dental Research Ethical Committee of the College of Dentistry, Qassim University (ST/56/2019). The personal information of the patients was kept confidential, and only the researchers were given access to the records.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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