Original Research

Comparison of the Distances between the Maxillary Sinus Floor and Root-Tips of the First and Second Maxillary Molar Teeth Using Panoramic Radiography among Dolichocephalic and Brachycephalic and Mesocephalic Individuals

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Abstract

Introduction: Comparison of the relationships and distance between maxillary root tips and the maxillary sinus floor using oral panoramic in the dolichocephalic and brachycephalic compared to mesocephalic individuals. **Methods:** Oral panoramic images from 300 individuals were analyzed and the relationships and distance between the maxillary root tips and the sinus floor was assessed by qualitative and quantitative variables. **Results:** The distance was significantly higher in the brachycephalic groups than that of the mesocephalic, and the mesocephalic group showed longer distance in comparison to dolichocephalic individuals. Qualitative comparison showed that type 1 relationship was the dominant position in the brachycephalic individuals while most of dolichocephalic individuals demonstrated type 2 and 3 relationships of the molar root tips and the maxillary sinus floor. **Conclusion:** Higher distances between the molar root tips and the maxillary sinus floor could be expected in the brachycephalic than mesocephalic and dolichocephalic individuals.

Key words: Maxillary sinus, Molar teeth, OPG, Maxilla.

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Introduction

Maxillary molar and pre-molar teeth and their roots are remarkable structures due to their close vicinity to the maxillary sinus. Maxillary sinus also known as antrum of Highmore is the largest of paranasal sinuses; a 15 cc volume pyramid-shaped air filled osseous cavity situated within the body of maxilla. Maxillary sinus is framed by the inferior orbital wall in the top, and (pre)molar teeth roots in the bottom (1). In 80-100% of the population the maxillary sinus is free of microbial organisms or foreign bodies (2,3). This sterility may be compromised by direct invasion of infections or endodontic interventions within the molar and premolar teeth. Contamination of maxillary air sinus renders highly morbid infections as well as oroantral fistulae or root dis-placement caused by the molar and premolar teeth extraction and implantation (4). It is demonstrated by Wehrbein and Diedrich in 1992 that longer molar root projection into the maxillary sinus measured in panoramic radiographs results in greater amount of pneumatization and sinus expansion after extraction which effectively reduced the bone thickness in which implantation will be performed (5). Protrusion of the

dental root apices into the sinus results in direct spreading of infections during endodontic therapy or during extraction causing maxillary sinusitis (6). Periapical surgical procedures of the upper molar teeth may be complicated by maxillary sinus wall aperture as described by Ericson et al. in 18% patients undergoing periodontic surgeries of maxillary molar teeth (7). The authors demonstrated that penetration of foreign bodies into the sinus cavity through the iatrogenic aperture can result in inflammation of the sinus mucosa initiating maxillary sinusitis process (7,8). Perforation of the sinus membrane is another potential complication of periapical surgeries in maxillary molar teeth. In the study by Persson, the rate of this complication was estimated as 44% of cases, but the overall surgical success rate was 78% which showed no significant negative effect of perforation of the sinus membrane on the prognosis of the surgery (9).

The relationship between maxillary molar root-tips and the sinus floor which constitutes the bone thickness supporting the roots is known to be an important determinant of the prognosis of orthodontic procedures involving the maxillary molars. A common dilemma in adult orthodontic treatment is deciding how best to treat missing posterior teeth. One treatment option is to orthodontically close the space. But closure can be difficult, especially if the open space is in the maxillary posterior area, because tooth movement through the maxillary sinus is limited (10).

Better knowledge of the distance between molar teeth root apices and maxillary sinus greatly influences conduction of surgical procedures on the upper molar and premolar teeth. Several studies have been carried out to measure this distance in normal populations by using computed tomography (CT) and cone-beam computerized tomography imaging. The highest distance was observed between maxillary floor and the first premolar root tip while the second molar distobuccal root tip was the nearest dental point to the maxillary sinus floor. There was no significant variation among male and female genders regarding this distances. Additionally, there was no variation of distances detected among right and left sides (11). Cephalic index has a close relationship with facial dimensions (12). There was no previous studies which focus of molars' root distance and the maxillary sinus floor in subjects with various cephalic indexes.

The aim of the present study was to compare the relationships and distance between maxillary root tips and the maxillary sinus floor using oral panoramic in the dolichocephalic and brachycephalic compared to mesocephalic individuals

Materials and Methods

This is a cross sectional study and the study material was comprised of a total number of 300 panoramic radiographic images obtained from randomly selected individuals referring to dental clinic of the Dentistry School of Shiraz University of Medical Sciences between September 1 ,2011 and October 31, 2012 . The research committee of the medical ethics group of Shiraz Medical Science University approved this study. Subjects eligible for study were as follow: having signed consent forms for participation in the study, having had a complete dentition in the maxilla and they were between 15-45 years old. Subjects were removed from the study if they had previous maxillofacial trauma, orthognathic surgery, reconstructive surgery, and implant procedures in the posterior of the maxilla. Study population consisted of 149 males and 151 females allocated in three study groups: dolichocephalic, mesocephalic, and brachycephalic; composed of 99, 98 and 103 cases, respectively. Oral panoramic radiographs were taken in radiology department of Shiraz Dentistry School using a Planmeca Proline XC digital orthopantomographic device. All radiographs were obtained in real size with using a device, though no magnification rate adjustment for measurement was applied.

Classification of the patients in the mesocephalic, dolichocephalic and brachycephalic groups was performed by measurement of cephalic index (CI) by calculating the ratio of width of the head above the ears to the length of the head from the forehead to the most prominent point of the occiput multiplied by 100 (12). CI values of 75-80 are categorized as mesocephalic or normal population. Values under 75 are classified in dolichocephalic and higher than 80 as brachycephalic groups. Measurements were performed clinically with real body size by recalling patients.

Panoramic images were evaluated for vertical relationship of root tips of the maxillary first and second molar teeth and the maxillary sinus floor. The distance between the apex of each root of mentioned teeth and the sinus floor was measured by built-in measuring tool of radiography viewing software provided by Regius 110 work station (Tokyo Japan). For qualitative evaluation of the maxillary root tip and inferior wall of the sinus we described 4 types of relationship and classified each root tip in one group. Type 1 was defined as cases in which the root was located in distant position from cortical borders of the Sinus. Type 2 represented the close contact of the maxillary root tip and maxillary sinus floor, and type 3 indicated overlapping of the root's shadow into the maxillary sinus without actual penetration into the cavity. (Fig. 1) Root apices protruding into the sinus cavity were categorized as type 4 relationship (Fig. 2). Undisrupted

lamina dura continuity was used to distinguish between type 3 and 4.

One observer (an oral and maxillofacial radiologist) measured the mentioned distances.

Distance measurement parameters and types of relationship for each root of first and second maxillary molar teeth of both sides were recorded in 3 study groups.

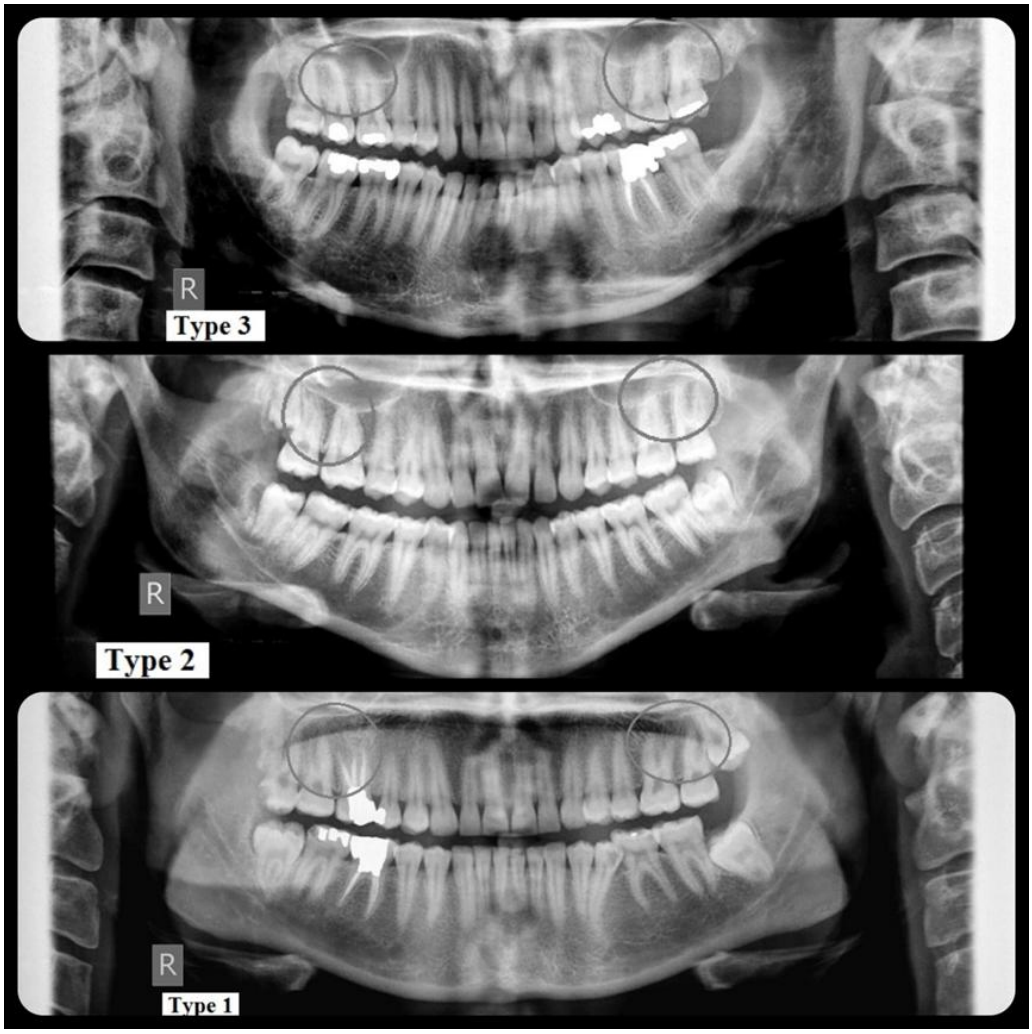

Figure 1. Panoramic radiographs demonstrating types 1, 2, and 3 of root tip to sinus floor relationship. Root apex is in close contact with maxillary sinus floor cortical bone (type 1). Root apex is overlapped by maxillary sinus shadow (type 2). Root tips are located distantly to the sinus floor.

Figure 2. Type 4 of root-maxillary sinus floor relationship .In the right side the first molar root penetrates to the maxillary sinus.

Statistical Analysis

The statistical analyses were performed using the statistical package SPSS for Pc, version 19 company. (IBM, USA). The statistical analysis was carried out to evaluate and compare of these parameters in dolichocephalic, mesocephalic and brachycephalic cases using descriptive t-test, ANOVA test and chi-square tests. P-values under 0.05 were considered as statistically significant values.

Results

In the present study, 149 males aging from 15 to 45 years with mean age of 31 years and 151 females aging between 15- 45 years with mean age of 27- 43 years were recruited. The study groups regarding the cranial anatomy were mesocephalic group containing 98 cases, dolichocephalic group consisted of 99 individuals, and brachycephalic group with 103 cases. Root tip distances to maxillary floor and relationship type of the root apices and maxillary sinus were recorded for a total number of 1200 right and left first and second molar teeth from all groups. Among all root tips, the type 2 vertical relationship defined as the root in contact with the sinus inferior wall, was the most frequent (38.1 %) qualitative relationship encountered (Table 1 a ,b).

Statistical analysis for variation among the first and second molar teeth regarding their qualitative relationship of root-tips and the maxillary sinus floor revealed a significant difference between the root-tips of the first and second molar teeth P<0.001). The most frequent type of relationship among first molar teeth was the type 1 while the type 2 relationship was more dominant among the second molar teeth. None of the root tips of the first molar teeth presented with the type 4 relationship while the frequency of the type 4 relationship in the second molar teeth was 2.4%.

The brachycephalic and dolichocephalic individuals were analyzed for variation of relationships between the first and second molar root apices and the maxillary sinus floor. A significant difference was detected for all root tips' positions related to the maxillary sinus. Also both the brachycephalic and dolichocephalic groups were separately compared to mesocephalic control cases which revealed significant positional variations (P-value<0.05) (Table 2).

Analysis of the data using an Independent T test showed significant variations in mean distances between the maxillary floor and the root tips of the first and second maxillary molar teeth. Root tips of the first molar teeth were found to be located significantly more distant to the sinus floor than the second molars (P-value for all roots < 0.05) (Table 3).

The distances between the molar root tips and the sinus floor were analyzed using ANOVA tests among studied cephalic anatomical groups which revealed significant variation of means. Mean distances between the root tips and the maxillary sinus were significantly lower in the dolichocephalic group than the mesocephalic individuals, and in the mesocephalic cases than the brachycephalic group. P-value for all studied roots were less than 0.001 (Table 4).

Table 1 a,b. Assessment of qualitative vertical relationship of maxillary molar root tips and the sinus floor in the left and right side.

Study Variables	Root	Type 1 N (Percent)	Type 2 N (Percent)	Type 3 N (Percent)	Type 4 N (Percent)	Chi-Square Test
Right first molar	Mesio-buccal root	144 (48.0)	90 (30.0)	66 (22.0)	0 (0.0)	
	Disto-buccal root	147 (49.0)	92 (30.6)	61 (20.3)	0 (0.0)	
	Palatal root	138 (46.0)	93 (31.0)	69 (23.0)	0 (0.0)	P<0.001
Right second molar	Mesio-buccal root	83 (27.7)	122 (40.7)	89 (29.7)	6 (2.0)	
	Disto-buccal root	73 (24.3)	126 (42.0)	90 (30.0)	11 (3.7)	
	Palatal root	86 (28.7)	120 (40.0)	89 (29.7)	5 (1.7)	

Table 1 b

Study Variables	Root	Type 1 N (Percent)	Type 2 N (Percent)	Type 3 N (Percent)	Type 4 N (Percent)	Chi-Square test
Left first molar	Mesio-buccal root	136 (45.3)	105 (35.0)	59 (19.7)	0 (0.0)	P<0.001
	Disto-buccal root	137 (45.7)	107 (35.7)	56 (18.7)	0 (0.0)	
	Palatal root	126 (42.0)	110 (36.7)	64 (21.3)	0 (0.0)	
Left second molar	Mesio-buccal root	72 (24.0)	138 (46.0)	85 (28.3)	5 (1.7)	
	Disto-buccal root	67 (22.3)	129 (43.0)	94 (31.3)	10 (3.3)	
	Palatal root	74 (24.7)	139 (46.3)	80 (26.7)	7 (2.3)	

Table 2. Assessment of vertical distance between maxillary molar root tips and the sinus floor

Cephalic Anatomy		Type 1 N (%)	Type 2 N (%)	Type 3 N (%)	Type 4 N (%)	Total
Dolichocephalic	First molar (right and left)	47 (23.7)	78 (39.4)	73 (36.9)	0 (0.0)	198
	Second molar (right and left)	20 (10.1)	82 (41.4)	89 (44.9)	7 (3.5)	198
Brachycephalic	First molar (right and left)	122 (59.2)	45 (21.8)	39 (18.9)	0 (0 .0)	206
	Second molar (right and left)	92 (44.7)	68 (33.0)	45 (21.8)	1 (0.5)	206
mesocephalic	First molar (right and left)	92 (46.9)	64 (32.7)	40 (20.4)	0 (0.0)	196
	Second molar (right and left)	42 (21.4)	103 (52.6)	50 (25.5)	1 (0.5)	196

Table 3. Comparison of the distance of roots to the maxillary sinus between the first and second molars

Study Variables	First Molar	Second Molar	Independent T test
Palatal	1.17 ± 1.6	0.54 ± 1.14	P<0.05
Mesio-buccal	1.16 ± 1.6	0.54 ± 1.16	P<0.05
Disto-buccal	1.22 ± 1.64	0.39 ± 1	P<0.05

Table 4. Comparison of the distance of roots to the maxillary sinus among various groups

	Root	Distance (mean)			ANOVA tests
		Dolichocephalic	Mesocephalic	Brachycephalic	
First Molar	Palatal	0.58 ± 1.32	1 ± 1.26	1.9 ± 1.92	0.000
	Disto-buccal	0.72 ± 1.46	1.02 ± 1.25	1.89 ± 1.91	0.000
	Mesio-buccal	0.71 ± 1.46	0.96 ± 1.19	1.79 ± 1.85	0.000
Second Molar	Palatal	0.09 ± 0.58	0.38 ± 0.84	1.1 ± 1.5	0.000
	Disto-buccal	0.015 ± 0.55	0.26 ± 0.67	0.9 ± 1.3	0.000
	Mesio-buccal	0.94 ± 0.63	0.4 ± 0.86	1.1 ± 1.5	0.000

Discussion

Appropriate knowledge of the distance and relationship between the posterior maxillary teeth root-tips and the maxillary sinus is important when endodontic and pre-prosthetic surgical procedures are planned. Protrusion of the maxillary molar root apices results in post-extraction pneumatization which causes reduction in bone thickness required for implantation. This assessment is critical when endodontic procedures are performed for maxillary molar teeth. In a study conducted by Ali and colleagues they compared the distance between molar root tips and maxillary sinus floor measured by CT imaging and panoramic radiography. Their study demonstrated that those roots which are detected to be protruding into the sinus cavity in panoramic radiography may be found non-protruding in CT scan evaluations (13). There is lack of evidence to show the correlation of thickness of maxillary sinus floor and other skeletal factors. Determining the effects of skeletal variations on the distance between molar root tips and the maxillary sinus floor helps the surgeons have better estimation of the risks and cautions which come along the desired procedure.

In the present study we used oral panoramic radiographs to evaluate qualitative and quantitative relationship between first and second maxillary molar root-tips and maxillary sinus floor and compared the values among the dolichocephalic and brachycephalic subjects.

Our study showed the roots of the first molar had more distance to the maxillary sinus floor than the second molars in all groups. This finding addressed the same results by Eberhardt et al (14). The same results were described by Pagin et al (15). Also, Huang et al reported that the first molar roots had more risk to displace the maxillary sinus rather than other posterior teeth (16).

Different of the root-sinus distance in various cephalic indexes was resulted in our study. The possible explanation is the change of cephalic index may affect maxillary vertical height and alter the distance between the maxillary sinus and the posterior teeth roots. This hypothesis was suggested in patients with isolated coronal synostosis by Farkas et al (17).

Regarding the results achieved by Ali et al in 2012 (18), and Arbel in 2006 (19), the mean distances measured by panoramic radiography were found to be significantly shorter than those measured in the same population by CT scan, but panoramic x-rays are equally informative as cone beam CT imaging. Though, we chose taking advantage of panoramic radiographs due to lower radiation exposure and hazards to study population.

There has been a clear finding that indicated importance of the relationships of the maxillary molars and the maxillary sinus. Kretzschmar and Obayashi demonstrated infections originating from the first and second maxillary molars could directly spread to the maxillary sinus. Protrusion of the root-tips into the maxillary sinus significantly increases post endodontic sinusitis and inflammations of maxillary sinus (14,20).

Comparison of the root-tips and the maxillary sinus relationship among the first and second molar teeth revealed significantly higher distance of the apex to the sinus inferior wall in the first molar teeth. Qualitative evaluation of the relationship also showed that the most frequently observed relationship in the first molar teeth was type 3 while type 1 was most frequent in the second molar teeth indicating close contact between the root-tips and the sinus inferior wall cortical border.

The mean distance between the apices of the maxillary posterior teeth and the floor of the maxillary sinus was measured from computed tomographic display data from 12 autopsy specimens and 38 human subjects. The distance from these apices to the adjacent lateral bony surfaces was also measured. The apex of the mesiobuccal root of the maxillary second molar was closest to the sinus floor (mean 1.97 mm) but farthest from the buccal bony surface (mean 4.45 mm). The apex of the buccal root of the maxillary first premolar was closest to the adjacent lateral bony surface (mean 1.63 mm) but farthest from the floor of the sinus (mean 7.05 mm) (21).

Sharan and Madjar studied correlation between maxillary sinus floor topography and related root position of posterior teeth using panoramic and cross-sectional computed tomography imaging. They concluded for the majority of the roots projecting on the sinus cavity in panoramic radiographs, no vertical protrusion into the sinus was observed in CT images. Roots that did protrude into the sinus in the CT showed a protrusion length that was much shorter than the projection length appearance using panoramic radiography (12). A study on Korean population showed the distance from the root apex to the inferior wall of the sinus was the shortest in the second molar area and the longest in the first premolar area. The thickness of the cortical plate of the inferior wall of the maxillary sinus was thinnest in the first premolar area but it was thickest in the second premolar area. The vertical relationship between the inferior wall and the roots of the maxillary molars was classified into five types. Type I (the inferior wall of the sinus located above the level connecting the buccal and lingual root apices) dominated (54.5% in the first molar area, 52.4% in the second molar area). The horizontal relationship between the inferior wall of the sinus and the root apex was classified into three types. Type 2 (the alveolar recess of the inferior wall of the sinus was located between the buccal and lingual roots) was most common (80% in the first and second molar area) (22).

A recent study showed the relationship between the roots of the maxillary molars and the sinus differed between the buccal and palatal roots. A root protruding into the sinus occurred more frequent in the buccal roots of the maxillary molars. The mesiobuccal root of the maxillary second molar was closest to the maxillary sinus floor and farthest from the alveolar cortical plate (17). Comparison of the distance between the root-tip and the sinus floor in various cephalic anatomic shape demonstrated that the mentioned distance was more in the brachycephalic individuals than the dolichocephalic individuals (1.86 mm versus 0.67 mm for first molar and 1.05 mm versus 0.06 mm for second molar teeth). In most of the cases allocated in the dolichocephalic group the type 1 and 2 relationships were observed indicating close contact and overlapping of the root apices and the sinus inferior wall, while the most frequently observed type in the brachycephalic patients was type 3 in which distant position of the root tip from the sinus floor was showed in panoramic images.

We did not use come beam computer tomography in this study .Regarding the high accuracy of CBCT in

measurement of the distance between molar roots and the maxillary sinus floor ,it has higher cost than OPG for patients and subjects may face more radiation dose.

Conclusion

In dolichocephalic population, the distance between the maxillary molar root apices are significantly lower than normal and brachycephalic subjects. This relationship has not previously been investigated and the novel finding may greatly help clinicians and surgeons' background knowledge of anatomical positions of molar root tips against maxillary sinus floor, for pre-endodontic and pre-implantation strategy making.

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