EGYPTIAN DENTAL JOURNAL

VOL. 64, 2205:2215, JULY, 2018

I.S.S.N 0070-9484

ORAL MEDICINE, X-RAY, ORAL BIOLOGY AND ORAL PATHOLOGY

www.eda-egypt.org • Codex : 92/1807

INTRAOBSERVER AND INTEROBSERVER RELIABILITY ASSESSMENT OF THE PROXIMITY OF MAXILLARY MOLARS TO THE MAXILLARY SINUS USING CONE-BEAM CT

Sara M. El Khateeb * *and* Ebtihal H. Zain-Alabdeen **

ABSTRACT

Purpose of the study: The aim of the current study was to evaluate the vertical and horizontal relationships between the root apices of maxillary molars and the maxillary sinus floor (MSF). And to examine the Intra- and Interobserver reliability of this assessments.

Materials and methods: This retrospective study was conducted at Taibah University Dental College & Hospital. We evaluated the vertical and horizontal relationships between the root apices of maxillary molars and the maxillary sinus floor according to modified classification from Kang et al. 2015 study. Kappa agreement coefficient was calculated to examine the intraobserver and interobserver reliability. Frequency and proportions were tabulated, and Generalized Estimating Equation (GEE) model analysis was performed for the test of significance.

Results: The sample contained 216 maxillary molars in total, with 56 missing molars, the analysis was performed on 160 maxillary molars. Kappa agreement coefficient was 0.9857 for intraobserver reliability and were 0.9799 and 0.9803, respectively for interobserver reliability. Concerning vertical measurements, the highest frequency was found in group two (58.8%) where there was close contact between maxillary molar root apices and MSF. For the horizontal relationship, most teeth were in the second group where the MSF is centrally located (37.5%).

Conclusion: Our study showed that most of the maxillary molars in our sample had close contact with floor of the maxillary sinus which was centrally located in most of our cases. Also, our study stated that the assessment classification was highly reliable that greatly will assist the clinician to relay on for the assessment and preceding knowledge of relationship between maxillary molars and maxillary sinus floor before any surgical dental procedures which is valuable for preoperative treatment planning and the inhibition of complications.

KEYWORDS: Reliability, Proximity, Maxillary molars, Maxillary sinus, CBCT

* Assistant Professor, Department of Oral Medicine, Periodontology, Diagnosis and Oral Radiology, Faculty of Dentistry, Ain Shams University, Cairo, Egypt.

** Lecturer, Department of Oral and Basic Clinical Sciences, College of Dentistry, Taibah University, Al-Madinah Al-Munawarrah, Kingdom of Saudi Arabia.

INTRODUCTION

The localization of teeth relative to maxillary sinus can be assessed by different radiographic techniques. Although panoramic radiograph is of significant assistance to the dental surgeon for preoperative assessment, it may have certain shortages such as distortion, blurred images and superimposition of two-dimensional images. Several studies assessed the vertical and horizontal relationship between the tooth root apex and the inferior wall of maxillary sinus using computed tomography (CT) or cone beam computed tomography (CBCT). [1]

One study found that the more posterior maxillary teeth, the more probability for root protruding into the maxillary sinus, and it is more common in male than female.[1] Although most of the studies concentrated on the relation of maxillary posterior molars to the maxillary sinus while other studies examined the relation of all posterior teeth to the maxillary sinus. However, some studies found that the hazards of violating the maxillary sinus border present only with few premolars during traditional or surgical endodontic treatment or in teeth extraction.[2, 3]

Abbas Shokri et al[1] have examined the relationship between maxillary sinus floor (MSF) and posterior teeth roots using (Jung, 2012)[4] classification, both intra and interobserver reliability was high for this classification, and found that although most of the teeth did not have contact with the sinus floor, the more posterior the maxillary teeth, the more probability for root protruding into maxillary sinus.

Evren OK et al.[3] also evaluated the relationship between the sinus floor and the maxillary posterior teeth by CBCT using their own classification (3 types), there was no intra or interobserver reliability test for the classification. In their study it was concluded that the maxillary first premolars aren't related to the MSF while maxillary second molars are closely related to it. Also, the second decade and males were most prone to undesirable results.

Arbel Sharan et al[5] and Maryam Shahbazian et al[6], both compared the assessment of panoramic radiography with CBCT imaging for radio-diagnostics in the posterior maxilla using their own classifications, and both concluded that CBCT imaging is a valuable radio-anatomic and radio-diagnostic examination in the posterior maxilla than panoramic radiography, neither one of these studies discussed the reliability of the CBCT assessment in this region.

These previous studies examined the relationship of maxillary posterior teeth in relation to the MSF, and concluded its superiority compared to panoramic radiography, however only two studies [(1,7)] examined the reliability of the qualitative and quantitative CBCT measurements.

Some of these studies used their own classifications and some used classification from previous studies, in this study we will choose one of these well-known classifications for the assessment of the proximity of maxillary molars roots to the MSF and apply it to our sample then examine the intraobserver and interobserver reliability.

Purpose of the study:

The aim of the current study was to evaluate the vertical and horizontal relationships between the root apices of maxillary molars and the maxillary sinus floor (MSF). And to examine the Intra- and Interobserver reliability of this assessments.

MATERIALS AND METHODS

This retrospective study was approved by Taibah University, College of Dentistry Research Ethics Committee "TUCD-REC", The study was conducted at Taibah University Dental College & Hospital (TUDCH) in Al Madinah Al Munawarah, Saudi Arabia.

The study included retrieving all the CBCT scans requested for evaluating the relationship of maxillary molars to the maxillary sinus floor from

2013 to 2017, these scans were acquired by the CS 9300 PREMIUM 3D CBCT device (Carestream SM 749, Rochester, NY, USA) and were stored in Carestream (CS) R4 Clinical and Practice Management Software database (CS Health, Inc. Rochester, NY, USA) of TUDCH.

CBCT images were selected taking into consideration a high-level of technical quality (i.e. proper sharpness, density and contrast), obviously displaying the maxillary posterior teeth apices and the sinuses floor. Cases presented with the following criteria were included in the study:

- Completely erupted bilateral maxillary molars.
- Maxillary sinus floor that was complete and wasn't damaged by disease.

Cases presenting with the following criteria were excluded:

- CBCT scans with artifacts like blurring by motion, or scatter, only clear scans were included.
- Cases with completely missing or unilaterally missing maxillary molars.

The linear measurement tool of the Carestream (CS) R4 Clinical and Practice Management Software used to record the measurements from the reformatted CBCT scans. The measurements recorded directly from the computer monitors. The scans from all volumes were observed on identical LCD monitors. The resolution of the monitors was set at the optimal resolution (1920·1200), the pixel size being 0.3 mm. Two oral and maxillofacial radiologists with at least 7 years experience made calibration to retrospectively examine the scans interactively using modified classification from Kang et al. 2015[7], and then each one read and did the measurements independently, to investigate the intraobserver reliability, one observer examined teeth for all CBCT images twice with two weeks interval.

The measurements recorded twice by both observers (in the morning and in dim lighting, two weeks in between) to evaluate inter-observer reliability of the used classification. The measurements recorded for each tooth categorized according to the used classification. The classification was modified and regrouped into millimeter ranges after the calibration in order to minimize interobserver differences.

The vertical relationship between the root apices of the maxillary molars and the Maxillary Sinus Floor (MSF) was classified as follows: (figure 1)

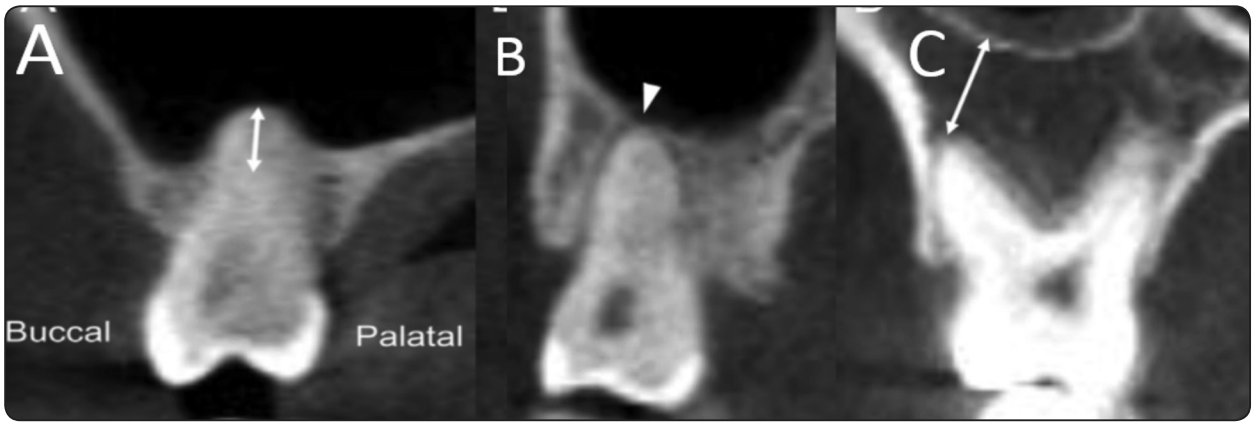

Fig. (1) Maxillary CBCT scans for the classification of the vertical relationship between the maxillary sinus floor and maxillary molars root apex. (A) Group 1: the root apex protruded into the maxillary sinus, (arrow) (B) Group 2: the root apex was in close contact with the MSF, (c) Group 3: the root apex was below the MSF, (arrow).

- **Group 1,** the root apex was protruding into the maxillary sinus cavity; three subcategories (1-2.9) mm, (3-7) mm and >7mm and a negative value was given for the distance.
- **Group 2,** the root apex was in close contact with the maxillary sinus floor (<1 mm);
- **Group 3,** the root apex was below the maxillary sinus floor. three subcategories (1-2.9) mm, (3-7) mm and >7mm and a positive value was given for the distance

For group 1: Distance measured by drawing a horizontal line as a base line at the lowest point of the sinus floor then measuring the distance from this base line along vertical line perpendicular to the root apex,

For group 3: the distance measured from the mid-point of the root apex in the cross-sectional CBCT section to the lowest point of the sinus floor, where all borders of roots are seen.

The horizontal relationship between the root apices of maxillary molars and maxillary sinus floor was classified as follows: (figure 2)

Group A, the lowermost point of the maxillary sinus floor was situated more to the buccal side than the buccal root;

Group B, the lowermost point of the maxillary sinus floor was situated centrally, comparative to the roots; and

Group C, the lowermost point of the maxillary sinus floor was situated more to the palatal side than the palatal root.

Group D, the lowermost point of the maxillary sinus floor was situated straight relative to the roots and not directed towards specific direction relative to roots.

Also, we assessed the presence of thickening of maxillary sinus mucosal lining and its association with existence of periapical lesion and cortication of maxillary sinus floor.

Statistical analysis:

Kappa agreement coefficient was calculated to examine the intraobserver and interobserver reliability. The association between the vertical or horizontal relations and sides (right and left) or

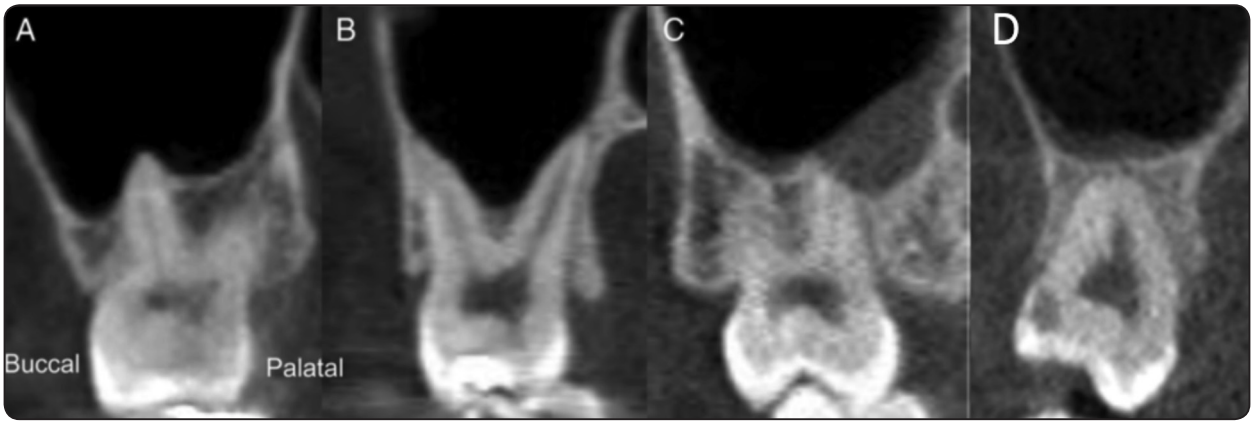

Fig. (2) Maxillary CBCT scans of the four groups for the classification of the horizontal relationship between the root apices of the maxillary molars and the maxillary sinus floor. (A) Group A: the lowermost point of the MSF was situated more to the buccal side than the buccal root. (B) Group B: the lowermost point of the MSF was centrally situated, comparative to the roots. (C) Group C: the lowermost point of the MSF was situated more to the palatal side than the palatal root. (D) Group D: the lowermost point of the MSF was straight and not directed towards specific direction relative to roots.

age (<27, 27-36, <37) were explored. Cortication in maxillary sinus and Maxillary Sinus (MS) Thickening were analyzed for their association with sides and age.

Association between MS Thickening and Lesions was examined and tested for statistical significance. Frequency and proportions were tabulated, and Generalized Estimating Equation (GEE) model analysis was performed for test of significance.

RESULTS:

The sample contains 216 maxillary molars in total, with 56 missing molars, the analysis was performed on 160 maxillary molars. The study incorporated 46 individuals who underwent CBCT in this period time were enrolled in the study and we excluded 7 unilateral cases so 39 cases only were included.

The intraobserver reliability between the first and second observations of one observer for all measurements resulted in Kappa agreement coefficient of 1 for both vertical and horizontal scores (100% agreement, Kappa=1) for all six teeth, except for the third group of vertical scores where the agreement was also very good, only one tooth had different scores, and overall Kappa was 0.9857.

For the horizontal observations, only 1 tooth had different categories, and overall Kappa was 0.9924. The agreement between the two observations of both observers were also very good, and their overall Kappa were 0.9799 and 0.9803, respectively.

The different categories were agreed on and used in the analysis.

There were 160 teeth: 58 for the first molar, 70 for the second molar, and 32 for the third molar. Both sides had similar number of molars: 81 (right) vs 79 (left).

Table 1 shows the frequency and percentages of vertical measurements for each of the six posterior teeth. Table 2 shows no significant difference in vertical relation between right and left molars combined. However, age was significantly associated with the vertical relation score (p=0.0232) (Table 3). Elder patients (age >37) had more molars with apex below the MSF than in younger patients (age <37), 39% vs 18%.

For the horizontal relationship between the maxillary molars roots and the MSF, most teeth were in the second group where the MSF is central (37.5%) followed by third group where the MSF is lingual (31.9%).

No significant difference was seen in the horizontal relation between right and left molars for A, B, C, and D groups, combined (all p-values >0.8695) (Table 4). However, age was significantly associated with the horizontal relation score (p=0.0002) (Table 5). Elder patients (age >37) had more lingual and straight MSF than in younger patients (age <37), 58% vs 21%.

Table 6 shows the frequency of cortication in maxillary sinus and comparison between right and left sides (p-value >0.6534), and between three age groups no significant differences were found (p-values >0.4150).

Table 7 shows the frequency of MS thickening and comparison between right and left sides, and between three age groups. Only marginally significant difference was found between right and left (p=0.0964), but not between three age groups (p=0.4749).

Table 8 shown the association between MS thickening and Lesions was significant (p=0.0033). Lesion was only seen when MS thickening score being 1 (yes).

TABLE (1) Vertical measurements for each of the posterior teeth:

Vertical observations	**Right side by teeth, N (%)**			**Left side by teeth, N (%)**			**Total**
	18	17	16	26	27	28	
1-2.9mm below	3(8.5)	10(28.6)	6(17.14)	4(11.43)	10(28.6)	2(5.7)	35
3-7 mm	2(25)	0	1(12.5)	4(50)	1(12.5)	0	8
>7mm	0	0	1(33.3)	1(33.3)	1(33.3)	0	3
Contact MSF	10(10.6)	24(25.5)	17(18)	16(17)	18(19.5)	9(9.5)	94
1-2.9mm protruded	0	0	0	2(33.3)	2(33.3)	2(33.3)	6
3-7mm protruded	2(14.3)	2(14.3)	3(21.4)	3(21.4)	2(14.3)	2(14.3)	14
Total	17	36	28	30	34	15	160

Note: there are 56 molars missing, percentages are presented by row

TABLE (2) Comparison: right vs left in vertical relation

Vertical observations	**Right side by teeth, N (%)**			**Left side by teeth, N (%)**			**p-value[A]**
	18	16	17	26	27	28	
Combined:							
Apex into MSF	2 (11.8)	3 (10.7)	2 (5.6)	5 (16.7)	5 (14.7)	4 (26.7)	0.3754
Apex contact MSF	10 (58.8)	17 (60.7)	23 (63.9)	16 (53.3)	18 (52.9)	9 (60.0)	.
Apex below the MSF	5 (29.4)	8 (28.6)	11 (30.6)	9 (30.0)	11 (32.4)	2 (13.3)	.

A From GEE model analysis.

TABLE (3) Comparison: Age effect on the vertical relation:

	Age, N (%)			**p-value [A]**
	17-26 years	**27-36 years**	**37 years and more**	
Combined Vertical observations:				
Apex into MSF	14 (21.21)	5 (9.43)	2 (4.88)	0.0232
Apex contact MSF	40 (60.61)	30 (56.60)	23 (56.10)	.
Apex below the MSF	12 (18.18)	18 (33.96)	16 (39.02)	.

A From GEE model analysis.

TABLE (4) Comparison: right vs left in Horizontal relation

Horizontal observations	**Right side, N (%)**			**Left side, N (%)**			**p-value[A]**
	18	17	16	26	27	28	
Combined:							
MSF Buccal	8 (47.1)	9 (25.0)	5 (17.9)	6 (20.0)	11 (32.4)	5 (33.3)	0.8695
MSF central	4 (23.5)	13 (36.1)	15 (53.6)	16 (53.3)	9 (26.5)	3 (20.0)	.
MSF lingual	3 (17.6)	13 (36.1)	8 (28.6)	7 (23.3)	13 (38.2)	7 (46.7)	.
MSF straight	2 (11.8)	1 (2.8)	. (.)	1 (3.3)	1 (2.9)	. (.)	.

A From GEE model analysis, percentages presented by column

TABLE (5) Comparison: Age effect on the Horizontal relation:

Horizontal observations	**Age**			**p-value [A]**
	17-26 years	**27-36 years**	**37 years and more**	
Combined:				
MSF Buccal	20 (30.30)	19 (35.85)	5 (12.20)	0.0002
MSF central	32 (48.48)	16 (30.19)	12 (29.27)	.
MSF lingual	13 (19.70)	18 (33.96)	20 (48.78)	.
MSF straight	1 (1.52)	. (.)	4 (9.76)	.

A From GEE model analysis

TABLE (6) Association of Cortication in M sinus with sides and age

	Cortication		**p-value[A]**
	No	**Yes**	
Side			
Right	10 (55.56)	71 (50.00)	0.6534
Left	8 (44.44)	71 (50.00)	.
Age			
17-26 years	5 (27.78)	61 (42.96)	0.4150
27-36 years	5 (27.78)	48 (33.80)	.
37 years and more	8 (44.44)	33 (23.24)	.

A from GEE model analysis.

TABLE (7) Association of MS thickening with sides and age.

	MS thickening			p-value [A]
	No	**Yes**	**Polypoid**	
Side				
Right	27 (61.36)	49 (49.00)	5 (31.25)	0.0964
Left	17 (38.64)	51 (51.00)	11 (68.75)	.
Age				
17-26	23 (52.27)	38 (38.00)	5 (31.25)	0.4749
27-36	12 (27.27)	33 (33.00)	8 (50.00)	.
37-	9 (20.45)	29 (29.00)	3 (18.75)	.

A From GEE model analysis.

TABLE (8) Association between MS thickness with lesions.

	Lesion		
	No	**Yes**	**p-value[A]**
Thickening			
0	44	0	0.0033
1	68	32	
2	16	0	

A From GEE model analysis.

DISCUSSION

Before both conservative and surgical endodontic procedures, dentists must be attentive of the close relationship between the roots of maxillary posterior teeth and the MSF to diminish the risk of generating communication between the oral cavity and the maxillary sinus.

Previous studies had assessed the position of the maxillary molars roots relative to the MSF in cadaveric samples[8, 9], panoramic radiographs[10,11], computed tomography [12,13], and CBCT scans [14,15] However, only two studies [1,7] examined the reliability of the qualitative and quantitative CBCT measurements. In the current study we evaluated intraobserver and interobserver reliability of a modified classification for the assessment of the proximity of maxillary molars roots to the MSF.

Even though, previous studies have evaluated maxillary roots protruding into maxillary sinus, but there were no standardized criteria for protrusion, and frequently the root apex may appear to protrude into the sinus in certain cuts of the scan but not in another plane of the volume [16].

Accordingly, we classified the maxillary molar roots that appeared to protrude into the sinus into group 1. While roots that were in contact with MSF in group 2, and roots that were below MSF were in group 3. This study examined the relationship of the root apex of maxillary molars to MSF both in vertical and horizontal directions.

Concerning the vertical relation between maxillary molar roots and MSF, the highest frequency was found in group 2 mainly in the right and left second molars (58.8%) where there was close contact between maxillary molar root and MSF. These results were inconsistent with a previous study where about 40% of cases were in group 1 (protruding into the sinus), [17] and another study claimed that 21.6% of cases were in close contact with MSF [18].

Kang et al. 2015[7] reported that 35% of roots were near the MSF, the different classification criteria used by Kang et al. study was the possible reason for this disagreement as they classified the root apices that were closely positioned to the MSF into two subgroups according to the level of the proximity.

This result is clinically significant because increased percentage of closely related maxillary molar roots to MSF. consequently, attention is required in any surgical treatment of the maxillary molars to avoid any complication.

There was no significant difference between right and left molars in vertical relationship (p values >0.1814). This was in accordance with previous studies [16,19] where there was no statistically significant difference between the two sides.

Our study reported that 12.5% of maxillary molar roots were protruded into MSF (group1). This was nearly like previous study stated that 14.3% cases protruding into the sinus [18]. Whereas, another research found 10.5% of roots were protruded [19].

In the present study, age was significantly associated with the vertical relation score (p=0.02). Elder patients (age >37) had more molars with Apex below the MSF than in younger patients (age <37), 39% vs 18%. This was dissimilar to previous studies where the frequency of group 1 decreased by increasing age (P < .05). This may be correlated to preceding findings that aging results in reduction of the maxillary sinus volume [20, 21].

For the horizontal relationship between the maxillary molars roots and the MSF, most teeth were in the second group where the MSF is central (37.5%). This was in harmony with Kang et al. 2015 [7] study, where the frequency of group 2 was higher. These results were consistent with a preceding study [22].

Our study found no significant difference was seen in the horizontal relation between right and left molars for A, B, C, and D, combined (all p-values >0.8695). However, age was significantly associated with the horizontal relation score (p=0.0002) (Table 5). Elder patients (age >37) had more molars MSF toward lingual and straight MSF than in younger patients (age <37), 58% vs 21%.

This was in disharmony with Kang et al. 2015 study that reported that there was no statistically significant difference found concerning age. However, additional study conveyed that the maxillary sinus was interposed more frequently in patients aged between 18 and 54 years than in those aged 55 years and older [15].

Our study found that only marginally significant difference was found between right and left MS thickening, (p=0.0964), but not between the three age groups (p=0.4749). Also, the association between MS thickening and lesions was significant (p=0.0033). Lesion was only found when MS thickening was present. This was in conformity with Shanbhag S. et al. 2013 [18] study where maxillary sinus mucosal lining thickening is a common radiographic finding in relative to teeth with periapical lesions. Sinus membrane thickening is present in 46.7% of patients presenting to an oral and maxillofacial surgical practice.

This was unlike to Block MS and Dastoury K. 2014 [20] study where the prevalence of sinus membrane thickening was nearly equal in relation with unhealthy and healthy teeth. The extraction of unhealthy teeth reduced, but did not entirely resolve sinus membrane thickening.

Our study reported that the Kappa agreement coefficient was 0.9857 for intraobserver reliability for the used classification and were 0.9799 and 0.9803, respectively for interobserver reliability. This was different from Kang 2015 [7] study where kappa values were 0.820 (intraobserver) and 0.763 (interobserver).

The results of the present study may support

clinicians in the management of patients, especially with endodontic problems in maxillary posterior teeth. For thorough treatment planning, CBCT examination is a noninvasive and clinically effective technique with this reliable classification for assessment of relationship of maxillary molar with maxillary sinus. [15, 23, 24].

CONCLUSIONS

Our study showed that most of the maxillary molars in our sample had close contact with floor of the maxillary sinus which was centrally located in most of our cases. Therefore, dentists must be particularly careful when performing periapical or pre-prosthetic surgical dental procedures involving the maxillary posterior teeth to avoid complications and enhancing the success of surgical and endodontic maneuvers.

Also, our study stated that the assessment classification was highly reliable that greatly will assist the clinician to relay on for assessment and preceding knowledge of relationship between maxillary molars and maxillary sinus floor before any surgical dental procedures which is valuable for preoperative treatment planning and the inhibition of complications.

REFERENCES:

1. Shokri A, Lari S, Yousef F, Hashemi L. Assessment of the relationship between the maxillary sinus floor and maxillary posterior teeth roots using cone beam computed tomography. The journal of contemporary dental practice. 2014;15(5):618-22.
2. von Arx T, Fodich I, Bornstein MM. Proximity of premolar roots to maxillary sinus: a radiographic survey using cone-beam computed tomography. Journal of endodontics. 2014;40(10):1541-8.
3. Ok E, Gungor E, Colak M, Altunsoy M, Nur BG, Aglarci OS. Evaluation of the relationship between the maxillary posterior teeth and the sinus floor using cone-beam computed tomography. Surgical and radiologic anatomy : SRA. 2014;36(9):907-14.
4. Jung YH, Cho BH. Assessment of the relationship between the maxillary molars and adjacent structures using cone beam computed tomography. Imaging science in dentistry. 2012 Dec 1;42(4):219-24.
5. 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 surgery, oral medicine, oral pathology, oral radiology, and endodontics. 2006;102(3):375-81.
6. Shahbazian M, Vandewoude C, Wyatt J, Jacobs R. Comparative assessment of periapical radiography and CBCT imaging for radiodiagnostics in the posterior maxilla. Odontology. 2015;103(1):97-104.
7. Kang SH, Kim BS, Kim Y. Proximity of posterior teeth to the maxillary sinus and buccal bone thickness: a biometric assessment using cone-beam computed tomography. Journal of endodontics. 2015 Nov 1;41(11):1839-46.
8. Kwak HH, Park HD, Yoon HR, et al. Topographic anatomy of the inferior wall of the maxillary sinus in Koreans. Int J Oral Maxillofac Surg 2004; 33:382–8.
9. Howe RB. First molar radicular bone near the maxillary sinus: a comparison of CBCT analysis and gross anatomic dissection for small bony measurement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 108:264–9.
10. 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;102:375–81.
11. Georgescu CE, Rusu MC, Sandulescu M, et al. Quantitative and qualitative bone analysis in the maxillary lateral region. Surg Radiol Anat 2012; 34:551–8.
12. Ariji Y, Obayashi N, Goto M, et al. Roots of the maxillary first and second molars in horizontal relation to alveolar cortical plates and maxillary sinus: computed tomography assessment for infection spread. Clin Oral Investig 2006; 10:35–41.
13. 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; 73:345–6.
14. Bornstein MM, Wasmer J, Sendi P, et al. Characteristics and dimensions of the Schneiderian membrane and apical bone in maxillary molars referred for apical surgery: a

comparative radiographic analysis using limited cone beam computed tomography. J Endod 2012; 38:51–7.

15. Kalender A, Aksoy U, Basmaci F, et al. Cone-beam computed tomography analysis of the vestibular surgical pathway to the palatine root of the maxillary first molar. Eur J Dent 2013; 7:35–40.

16. 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: 1541–8.

17. Wallace JA. Transantral endodontic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996; 82:80–3.

18. Shanbhag S, Karnik P, Shirke P, Shanbhag V. Association between periapical lesions and maxillary sinus mucosal thickening: a retrospective cone-beam computed tomographic study. Journal of endodontics. 2013 Jul 1;39(7):853-7.

19. 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; 4:462–7.

20. Block MS, Dastoury K. Prevalence of sinus membrane thickening and association with unhealthy teeth: a retrospective review of 831 consecutive patients with 1,662 cone-beam scans. Journal of Oral and Maxillofacial Surgery. 2014 Dec 1;72(12):2454-60.

21. Ariji Y, Kuroki T, Moriguchi S, et al. Age changes in the volume of the human maxillary sinus: a study using computed tomography. Dentomaxillofac Radiol 1994;23: 163–8.

22. Jung YH, Cho BH. Assessment of the relationship between the maxillary molars and adjacent structures using cone beam computed tomography. Imaging Sci Dent 2012;42:219–24.

23. Kim SY, Kim BS, Woo J, Kim Y. Morphology of mandibular first molars analyzed by cone-beam computed tomography in a Korean population: variations in the number of roots and canals. J Endod 2013;39:1516–21.

24. Rigolone M, Pasqualini D, Bianchi L, et al. 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;29:773–5.