The Relation of Maxillary Posterior Teeth Roots to the Maxillary Sinus Floor Using Panoramic and Computed Tomography Imaging in a Sample of Kurdish People

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Abstract

The relation of maxillary posterior teeth roots to the maxillary sinus floor is important for diagnosing and planning of many surgical procedures. In order to determine of this relation two imaging technique were used in this study.

Paired panoramic radiographs and computed tomography images of maxilla from 27 subjects were taken and analyzed in the teaching hospitals of Sulaimani city during the period from Jan to Aug 2009. For both imaging modalities a total of 146 maxillary teeth were grouped according to their topographic relationship to the inferior border of the maxillary sinus followed Kwak et al. classification, were 0 indicated no contact between the root and inferior border of the maxillary sinus); 1 indicated that the root is in contact with the inferior border of the maxillary sinus; 2 indicated that the root is projecting laterally on the maxillary sinus cavity but its apex is outside the sinus boundaries; 3 and 4 indicated that the teeth roots that projected on the maxillary sinus cavity. Then roots were measured according to their projection lengths in the sinus cavity.

Results of this study show that there was a high correlation between the two imaging technique for classification 0 and 1 relations. The OPG showed statistically significant ($P<0.001$) longer root projection in the sinus cavity in comparison with the root protrusion into the sinus measured by using CT images.

As conclusion; 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 protrude into the sinus in the CT showed shorter projection length in comparison with panoramic radiography. Panoramic radiographs can provide adequate assessment about relation of the maxillary sinus floor. CT is indicated to provide the information about the relation to the maxillary sinus floor when there is protrusion detected in panoramic images.

Introduction

The maxillary sinus (antrum of Highmore) is the first of the paranasal sinuses to

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develop and ends its growth at approximately 20 years of age with the eruption of the maxillary third molars[1,2]. The adult sinus is variable in its extension. Its floor extends between adjacent teeth or

between individual roots in about half of the population, creating elevations in the antral surface (commonly referred to as "hillocks") or protrusions of root apices into the sinus[2].The roots of the maxillary first and second molars are in intimate relation to the floor of the maxillary sinus in most cases, in some cases the apices of these teeth protrude into the sinus, and the sinus membrane must be raised surgically in order to treat lesions related to them[3,4] .Knowledge of the relationship between the root apex and the inferior wall of the maxillary sinus are crucial for diagnosing and treating sinus pathology as well as in assisting in dental implantation. Accordingly, knowledge of the topography between the root apex and the inferior wall of the maxillary sinus is important for diagnosing and planning dental implantation, endodontic procedures, and orthodontic treatment[5]. Many studies have been performed on the vertical relationship between the root apex and the maxillary sinus floor using many modalities. The purpose of this study is to correlate the topographic relationship of the maxillary sinus floor to the maxillary posterior teeth roots as imaged by pairs of panoramic imaging radiographs (OPG) and computed tomography (CT) images.

Material and Method

Pairs of radiographic images OPG and CT were taken for 27 patients (16 males and 11 females), during the period from Jan to Aug.2009. Images were assessed for the root apices of the maxillary posterior teeth and the sinus floor. All the individuals had no pathological condition in the sinus and were dentulous. Their age range was (20-55) years old with mean age of (29) years. CT images were taken at Sulaimani Teaching Hospital Radiology Department using Computed tomography system (SOMATOM AR.STAR VB41A H-PR-CR). The machine had been used with exposure parameters of (130) KV, (105) mA, TI 1.9, GT -2.0, SL 3.0/7.0. The panoramic radiographs were taken at Peramerd Dental Teaching Hospital Radiology Department using digital radiographic system (PLANMECA

DIMAX 3.0). The machine had been used with exposure parameters of (66) KV, (10) mA, and (18) seconds exposure time, and high resolution. The magnification rate of the images was considered in measurement according to the equation: (estimated size /1.2= real length according to the manufacturer instruction).The second premolars, the first molars and the second molars were assessed in this study because these are the teeth for which root apices are closest to the maxillary sinus floor [5,6]. The topographic relationship of each root of the above teeth to the maxillary sinus floor was qualitatively classified in both imaging techniques under standard conditions of illumination by same examiner following Kwak et al. (2004) classification[5]. (Fig 1) as follow; Classification 0; The root is not in contact with the cortical borders of the maxillary sinus. Classification

1: An inferiorly curving maxillary sinus floor, the root is in contact with the cortical borders of the sinus. Classification

2: An inferiorly curving maxillary sinus floor. The root is projecting laterally on the sinus cavity but its apex is outside the sinus boundaries the root is projecting laterally on the maxillary sinus cavity but its apex is outside the sinus boundaries. Classification

3: An inferiorly curving maxillary sinus floor, the root apex is projecting in the sinus cavity. Classification 4: A superiorly curving maxillary sinus floor enveloping part or the entire tooth root. In cases with roots classification (3) or (4), the length of the apical part of the root superior to the sinus inferior wall was measured digitally using system software in both radiographic techniques. In the panoramic radiograph, this measurement represents the radiographic projection of the root on the sinus cavity, and in the CT it represents the protrusion of the root into the sinus. Data was analyzed using SPSS program version 16.0. to get descriptive, inferential (Chi-square test and t-test) correlation and regression statistics. P-values <0.05 were regarded as statistically significant.

Results

The study includes 146 maxillary posterior teeth (52 second premolars, 45 first molars, and 49second molars) from 27 subjects (16 males and 11 females) (table1). The percentage of finding the same classification in both radiographic techniques was 56.8 % (83 teeth out of 146) (table 2). Chi-square test showed highly significant difference between the classifications given for the same root in the panoramic radiograph and in the CT images (chi-square = 140.0; df= 16; P<0.001). In classifications (0) and (1), the pairs of panoramic radiographs and CT images showed the same classification in 86% to 74% of the cases respectively (table 2). Concerning the type of teeth, in panoramic radiograph at classification (2), 2nd premolars that projected on the anterior wall of the sinus were 12 cases, while the 2nd molars that projected on the posterior wall of the sinus were only 3 cases. This is greatly differs from that seen in CT(table1). When the cross-sectional CT images showed roots with classification (2), most of the panoramic radiographs (72.7%) showed them in classification (3) (figure 2 and 3). indeed, 72.7% of the roots of the upper posterior teeth with classification (2) in the CT images were projecting on the sinus cavity in the panoramic radiograph. Furthermore, when the panoramic images classification was (3), the CT images showed the same classification in only (25%) of the cases, and almost all the other cases showed a lower classification. But when the panoramic images classification was (4), the CT showed the same classification in only (33%) of the cases and all the other cases presented a lower classification. Finally, when the CT images classification was (3) and (4), the panoramic radiographs showed the same classification in 100% of the cases. Eleven pairs of panoramic radiographs and CT images showed teeth roots practically protruded vertically into the sinus cavity (figure 4). The mean values of the root-projection lengths in the panoramic radiographs was (4.65 ±1.17 mm) and it is statistically higher than the root-protrusion

lengths in the CT images (2.55 ±1.20 mm) (t -test=5.33; df=10; P< 0.001)(table 3 and figure 5). The data showed that the root projection length in the panoramic radiograph was 1.82 times larger than the actual root protrusion length in the CT images. From the regression analysis that was statistically, the following formula was deduced to predict the root protrusion length in the CT from the root projection or length in the panoramic radiograph; (Root protrusion length in CT)= 0.3 + 0.38 × (root projection length in the OPG)

Discussion

Analysis of the results showed a high correlation (74% to 86%) between panoramic radiography and CT in subjects with the roots of upper posterior teeth classified as (0) or (1). In these cases, the 2-dimensional panoramic image is sufficient to provide the clinician with the information about the true relationship between the teeth roots and the sinus. A nearby tendency was reported by Arbel who showed the same results in (86% to 96%) of the cases [7]. In subjects that showed roots projecting on the sinus cavity in their panoramic radiographs (classification **3**), only 25% showed protrusion into the sinus in the CT images, and almost all of the other cases presented a lower classification. Closely-related results were reported in other studies. Freisfeld et al. (1993) found that out of 129 roots, 64 seemed to penetrate into the maxillary sinus in the panoramic radiographs [8], but only 37 roots showed penetration in the CT images. Bouquet et al . (2004) found that out of thirty 3rd molars roots that projected on the sinus in panoramic radiographs, and seven 3rd molars roots (about 23%) didn't penetrate the sinus in CT images[9]. Arbel in his study showed (39%) protrusion into the sinus in the CT images [7]. This can be explained by the 2-dimensionality of the panoramic radiograph, which causes roots that are buccal/lingual to the sinus to be projected on the sinus cavity, indeed, 72.7% of the roots of the upper posterior teeth with classification (2) in the CT images were projecting on the sinus cavity

in the panoramic radiograph. Therefore, when presented with a panoramic radiograph alone, the clinician cannot determine whether the root is actually protruding into the sinus or not, this is in contrast to the cross sectional image of the CT, which allows an accurate interpretation (within the limitations of the sharpness of the image) of the true bucco-lingual relationships of the teeth roots to the sinus, any part of the root that is superior to the maxillary sinus floor in the CT should be protruding into the sinus, this was reflected in the results of the study 100% of the cases that showed a root protruding vertically into the sinus in the CT also showed root projection on the sinus in the panoramic radiograph. While in subjects that presented a superiorly curving sinus floor in their panoramic radiographs (classification), only 33% showed the same classification in the CT image, whereas all the other cases presented a lower classification, this can be explained by the fact that the sinus floor seems flat when inspecting single cross-sections of the tooth root in the CT. A detection of the superiorly curving topography of the sinus floor in these cases may be achieved by noting the supero-inferior changes of the inferior cortical border of the sinus in several cross-sections. The present study also investigated the projection and protrusion lengths of the teeth roots superior to the sinus floor in classifications (3) and (4) as imaged by panoramic radiographs and the CT images. The panoramic radiographs consistently showed a 1.8 times longer projection of the root on the sinus cavity in comparison to the root protrusion length into the sinus in the CT, with no significant differences between root types.

A similar significant difference was found by other author when dealing with 3rd molars [9]. This result is again explained by the 2-dimensionality of the panoramic radiograph, and it occurs when sinus recesses penetrate into inter radicular area. In these cases, the panoramic radiograph will show a significant part of the root projecting on the sinus, but the CT will show that only the apical part of the root (48% of the measured projection depth in the panoramic radiograph) penetrates the sinus and the rest is medial/lateral to it. Previous study indicated that panoramic radiographs consistently showed a 2.1 times longer projection of the root on the sinus cavity in comparison to the upper posterior roots protrusion length into the maxillary sinus in the CT images[7] . The large difference between the 2 imaging techniques cannot be explained simply by the vertical magnification of the panoramic image because it is only 10% to 30% . Other clinician observing upper posterior roots projecting on the maxillary sinus cavity in the panoramic radiograph should be aware that an average of only 25% of these roots are truly protruding vertically into the maxillary sinus and that the protrusion length is much shorter than that appearing on the panoramic radiograph[10]. In conclusion the majority of the cases evaluated for the relation of the posterior teeth relation to the maxillary sinus (approximately 80 %), panoramic image is sufficient for evaluation. In the cases that the root protruded to the maxillary sinus in panoramic radiograph CT is needed to provide the true relationship.
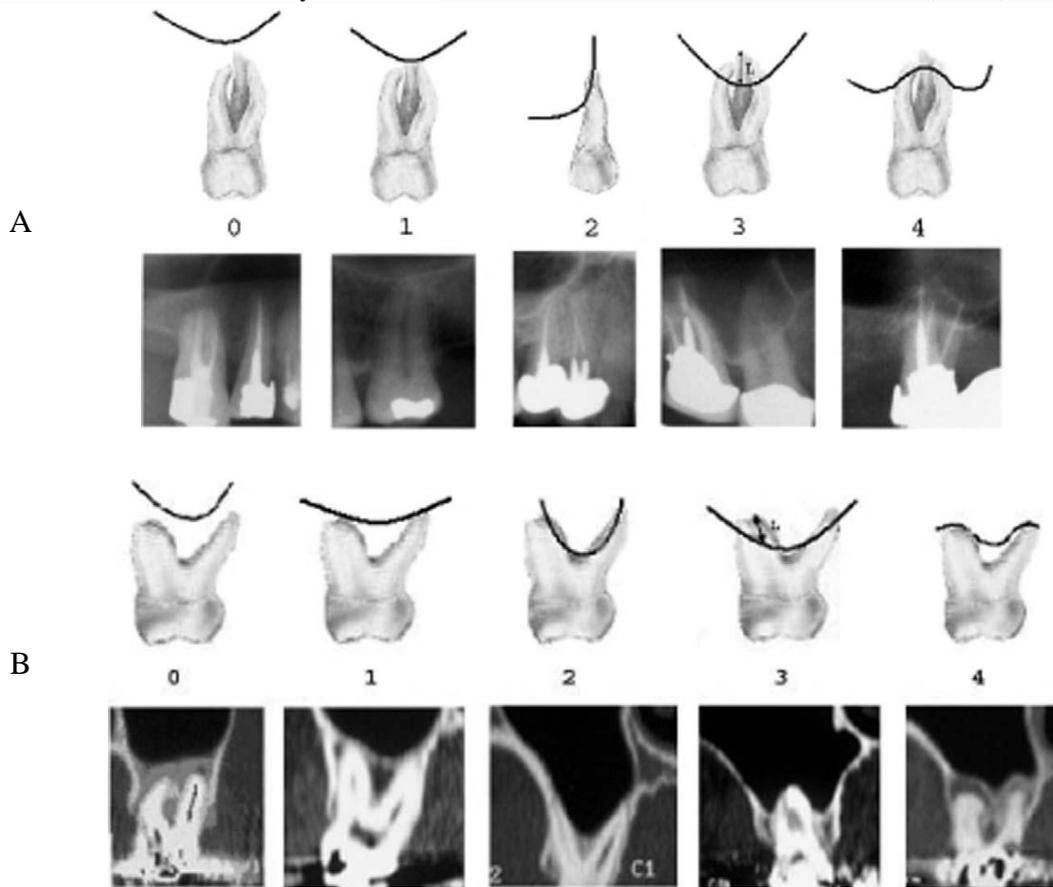
Fig. (1):- Schematic illustrations for **Kwak** et al classifications of the maxillary posterior teeth roots in relationship to the inferior wall of the maxillary sinus[5] (A) panoramic images (B) cross-sectional CT images.
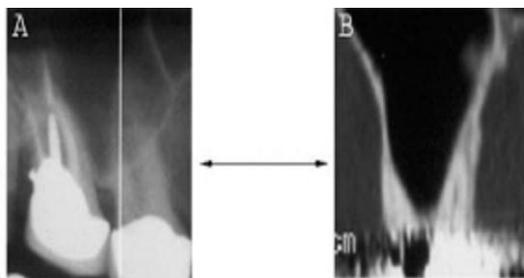

Fig. (2):- Radiographic images of roots projecting on the sinus cavity in the panoramic radiograph, but only lateral to the sinus in the CT image. A, section of the panoramic radiograph showing classification 3 for the 1st molar roots, (marked longitudinal white line indicates the location of the cross-sectional image of the CT). B, cross-sectional image showing classification 2 for the same tooth.
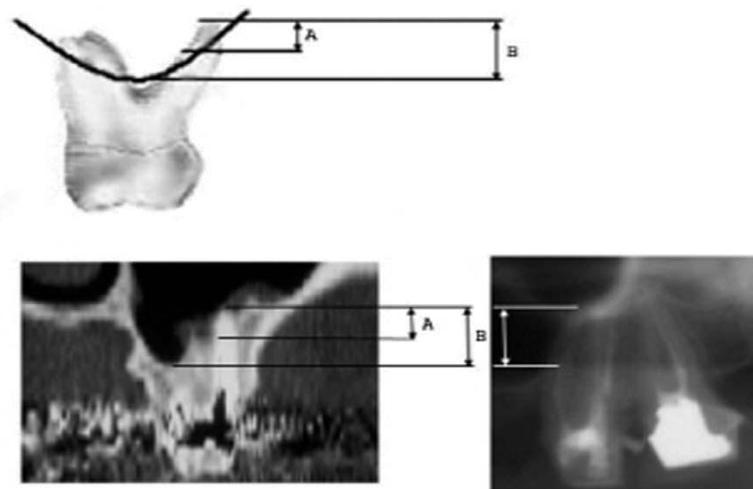

Fig. (3):- Schematic illustration and radiographic images of the difference between root protrusion into the sinus in the CT and root projection on the sinus cavity in the panoramic radiograph. A, root protrusion length measured on cross sectional CT image. B, Root projection length measured on the panoramic radiograph.
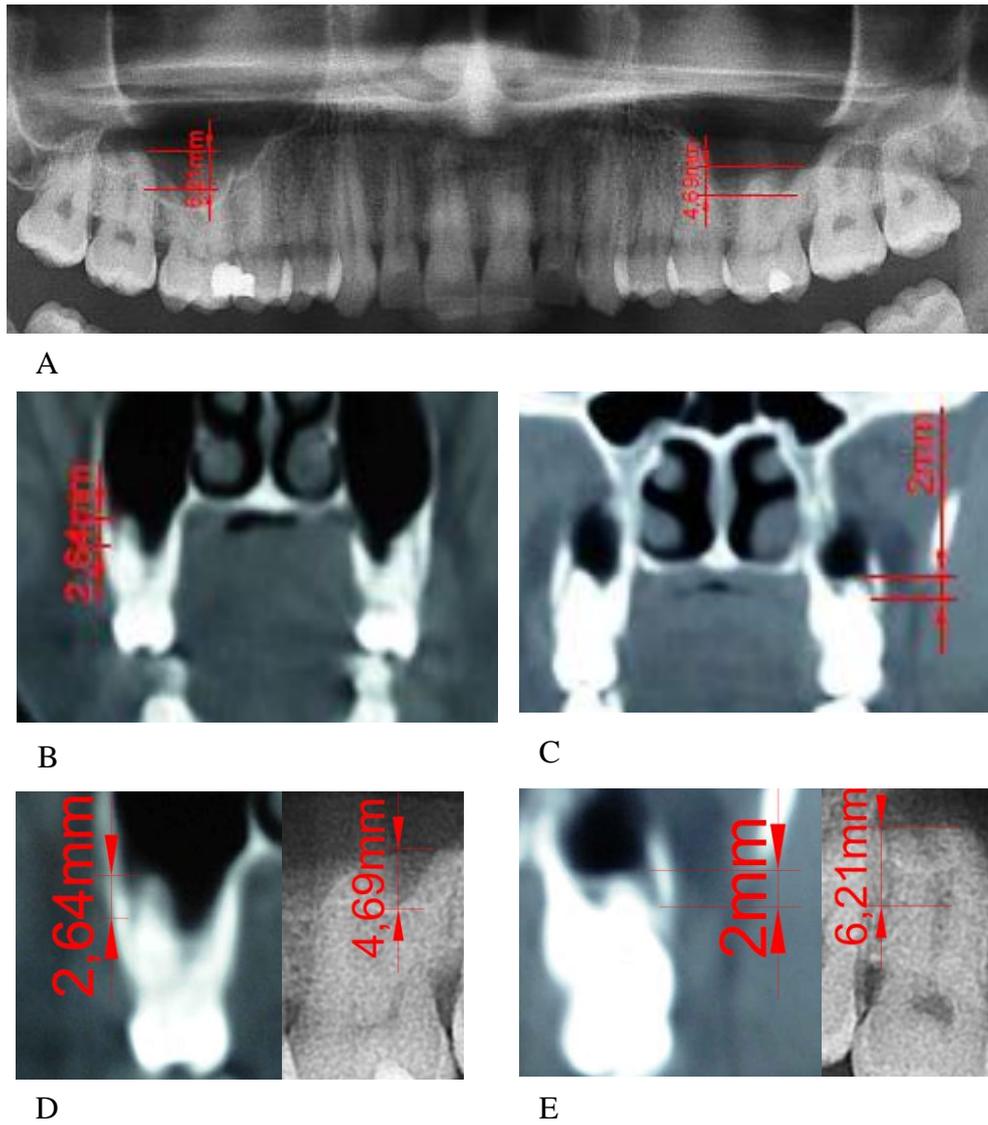
Fig. (4):- Images for a patient with bilateral maxillary posterior teeth roots projection in the maxillary sinus (upper right 2nd molar and left 1st molar). Measured values of the root-projection lengths in OPG and root-protrusion lengths in the CT images are shown. (A) OPG radiograph. (B and C) CT image. Higher zooming view for the requested teeth from above both images for right (D) and left (E) were shown.
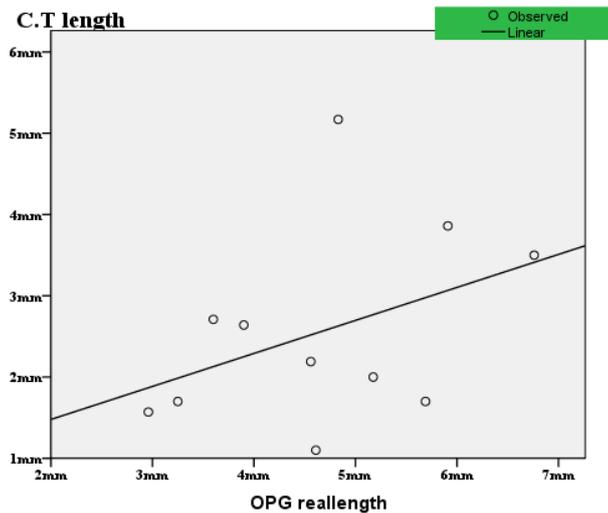

Fig. (5):- A scatter plot and regression line of the projection lengths of the maxillary roots in panoramic radiographs versus protrusion lengths of the same roots in CT images.

Table (1):- Frequency distribution of the maxillary posterior teeth according to tooth type, radiograph technique and Kwak et al. classification.

Tooth		Radiograph	Classification				
Type	No.		0	1	2	3	4
2nd premolar	52	OPG	30	5	12	5	0
		CT	28	22	0	2	0
1st molar	45	OPG	11	17	0	16	1
		CT	12	21	6	6	0
2nd molar	49	OPG	3	24	3	11	8
		CT	14	27	5	0	3
Total	146	OPG	44	46	15	32	9
		CT	54	70	14	10	3
Total of both techniques			98	116	26	40	12

Table(2):- Cross distribution of maxillary teeth roots according to Kwak et al. classification in panoramic radiography and CT cross-sectional images.

	classification	0	1	2	3	4	Total OPG
No.	0	38	6				44
% within OPG		86.4	13.6	0	0	0	100
% within CT		70.4	8.6				30.1
No.	1	11	34	1			46
% within OPG		23.9	74	2.2	0	0	100
% within CT		20.4	48.6	9.1			31.5
No.	2		15				15
% within OPG		0	100	0	0	0	100
% within CT			21.4				10.3
No.	3	2	14	8	8		32
% within OPG		6.2	43.8	25	25	0	100
% within CT		3.7	20.0	72.7	100		21.9
No.	4	3	1	2		3	9
% within OPG		33.3	11.1	22.2	0	33.3	100
% within CT		5.6	1.4	18.2		100	6.2
Total CT		54	70	14	10	3	146
% within OPG		37	47.9	7.5	5.5	2.1	100
% within CT		100	100	100	100	100	100

Table (3):-Mean length value of root projection in OPG and protrusion in CT images and their ratio.

Imaging technique	No.	Mean± sd (mm)	OPG/CT ratio
OPG	11	4.65 ±1.17	1.82
CT	11	2.55 ±1.20	

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