

## ORIGINAL RESEARCH

### **Comparative radiographic assessment among upper molar roots invading maxillary sinus**

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#### **ABSTRACT**

**Purpose:** This study investigated correlations between findings on panoramic radiographs and cone-beam computed tomography (CBCT) to assess the relationship between the maxillary sinus floor and the roots of maxillary posterior teeth. In addition, radiographic signs indicating actual root protrusion into the maxillary sinus were evaluated on panoramic radiographs.

**Methods:** A total of 250 maxillary posterior teeth who underwent panoramic radiography and CBCT were enrolled. The relationship between the posterior teeth and the maxillary sinus and panoramic radiography signs associated with protrusion of root apices into the sinus were evaluated.

**Results:** There were differences between the imaging modalities about the positioning of the root apices regarding the sinus ( $p < 0.05$ ). Only the projecting of the root apices and the interruption of the sinus floor on panoramic radiography were predictors for the root protrusion ( $p < 0.05$ ).

**Conclusions:** Knowledge of anatomical relationship between the maxillary posterior teeth and maxillary sinus guides not only in proper preoperative treatment planning but also avoids the possible complications encounter while performing the minor oral surgical procedures involving maxillary posterior teeth, which are close to the maxillary sinus.

#### **INTRODUCTION**

The maxillary sinus is the largest paranasal sinus, and the topography of the maxillary sinus floor is extremely variable. The position of the roots relative to the sinus floor has several important clinical implications.<sup>1</sup> Surgical removal of upper posterior teeth is a routine procedure in which complications occasionally arise. Oroantral communications might occur after dental extractions, given the anatomical proximity between the upper posterior dental roots and the maxillary sinus. This accident, which has always been a concern for dental practitioners,<sup>2</sup> consists in the violation of the maxillary sinus floor and may or may not involve tearing of the Schneiderian membrane.<sup>3,4</sup>

Maxillary sinus starts developing during intrauterine fetal life which continues to develop even after birth. Size and shape of adult maxillary sinus are variable, and it may differ according to age of an individual, their size, and degree of pneumatization.<sup>5,6</sup> Maxillary sinus

often expands between the molar roots and results in proximity between them. On radiograph, it seems that roots penetrate the sinus floor and protrude into maxillary antrum, but instead, it is the maxillary sinus that has extended around the roots of the tooth. Panoramic radiograph are frequently used to evaluate teeth and patterns of the craniofacial skeleton, serving as a guide for their diagnosis and planning<sup>11</sup>. Furthermore, some ghost images are formed on the opposite site of the object, mesiodistal and vertical enlargement, adding a limitation to evaluating the anatomic correlation between tooth roots and alveolar bone when using only a panoramic radiography.<sup>7</sup>

CBCT examinations are also reliable for linear measurement. Furthermore, despite the difference in radiation between CBCT and 2D images, it has been demonstrated that decreasing the field of view (FOV) helps reducing radiation dose, resulting in 2.7 to 23 mSv for a panoramic and 34-89 Sv for the CBCT. Both modalities have less radiation than Computed Tomography.<sup>8,9,10</sup> Lopes et al.<sup>18</sup> and Themkumkwun et al.<sup>19</sup> investigated panoramic radiographic signs indicating actual protrusion of the roots into the maxillary sinus.<sup>11,12</sup>

The purpose of this study was to investigate correlations between findings on panoramic radiography and CBCT for evaluating the relationship between the maxillary sinus floor and the roots of maxillary posterior teeth. In addition, radiographic signs indicating actual root protrusion into the maxillary sinus were evaluated on panoramic radiographs.

## **MATERIALS AND METHODOLOGY**

The local research ethics committee approved this work without restrictions. The sample consisted of 250 maxillary posterior teeth of individuals whose records were available in the image database of an oral radiology clinic.

Each root of the first and second molars was used in the qualitative and quantitative evaluations. An assessment of the topographic relationship of each root to the maxillary sinus floor was conducted in both panoramic radiograph and in CBCT images by three oral radiologists who acted as evaluators of the research for at least 3 years. Under dim light conditions, they blindly evaluated the images as described by Sharan and Madjar (2006)<sup>7</sup>, using the following scoring system: 0, the apices of the root is not in contact with the cortical borders of the sinus;

1 the apices of the root is in contact with the cortical borders of the sinus;

2 the root is projected laterally to the sinus cavity, and an apices is in contact with the cortical borders sinus;

3 the apices is projecting in the sinus cavity, and;

4 the maxillary sinus has a buckle that goes round the root of the tooth, but its apices is just in contact with the cortical borders sinus. All cases in which the qualitative assessment of the root was scored 0 were given a positive number, those with 1, 2, 4 were numbered as 0 mm, and those with qualitative assessment 3 were given a negative number as a means of quantitatively assessing the length of the apical part of the root superior to the sinus inferior wall.

Through the correlation between panoramic radiography and CBCT, the mode for qualitative assessments and the average for quantitative obtained by the three observers in both imaging modalities, for all dental roots was calculated.

## **STATISTICAL ANALYSIS**

Statistical analyses were performed with the Statistical Package for the Social Sciences SPSS® v. 22 (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL). Information from CBCT images was used as the reference standard. Contingency cross-tables with scores

given for panoramic radiographic images and for the reference standard, CBCT, were created. A p-value <0.05 indicated the presence of a significant difference.

## RESULTS

**Table 1: Contingency table comparing scores of the root–maxillary sinus relationship from CBCT (reference standard) and panoramic radiography (PR)**

		PR				
Imaging modalities	Scores	0	1	2	3	Total
CBCT	0	30	25	20	18	93
	1	20	17	18	17	72
	2	15	12	9	12	48
	3	10	11	8	8	37
Total		75	65	55	55	250

p,0.05, according to McNemar–Bowker test.

**Table 2: Multiple logistic regression for possible radiographic signs indicating root protrusion into the maxillary sinus (MS)**

Variable	Standard Error	Z	p-value	Odds Ratio	95% CI
Intercept	0.30	-	-	-	-
Projection of root onto MS cavity	0.45	8.01	<0.05	45.90	16.79–123.60
MS floor discontinuities	0.40	-2.55	<0.05	0.39	0.25–0.65
Absence of lamina dura	0.37	-0.41	0.6728	0.79	0.41–1.78
Darkening of root apices	0.39	1.22	0.2113	1.50	0.65–2.85
Kinked MS floor enveloping the root	1.48	1.65	0.0929	12.50	0.56–215.20

CI, confidence interval

CBCT images indicated that 37 teeth (14.8%) penetrated into the maxillary sinus cavity, whereas 93 (37.2%) were at a discernible distance from the maxillary sinus floor.

Panoramic radiography and CBCT scores regarding the relationship between maxillary posterior teeth and maxillary sinus floor are shown in Table 1. In general, 130 (71.5%) cases showed agreement on the positioning in both imaging modalities. Good agreement was verified for 30 teeth that were distant from the sinus and for 8 teeth that protruded into the sinus cavity. For scores in the mid-range, there was disagreement between the two modalities, with agreement generally <50%. There was significant disagreement between panoramic radiographs and CBCT, for those teeth with a root projection score of 2 or 3 on the panoramic radiographs, which overestimated the projection of the roots into the sinus. Similarly, panoramic radiographs also tended to underestimate the distance between the roots and the sinus, as seen when comparing teeth with panoramic scores of 0 and 1 and the CBCT of those teeth.

Table 2 summarizes the panoramic radiography signs tested as indicators of an intimate relationship between roots and the maxillary sinus floor. Only the projection of the root apices on the sinus cavity and the interruption of maxillary sinus floor's cortex were considered as statistically relevant indicators (p<0.05).

## DISCUSSION

This goal of this study was to compare the qualitative and quantitative information provided by panoramic radiography to CBCT in order to assess the relation between maxillary sinus

and the apices of the maxillary posterior teeth with or without some kind of pathology. It is very crucial to assess the relationship between maxillary posterior teeth roots and floor of the maxillary sinus before planning any treatment procedure to avoid any procedural complication. Many potential risks are associated with maxillary posterior root tips in proximity to the sinus floor. Many studies have examined the prevalence of roots protruding into the maxillary sinus, with various results.

Several studies found that the mesiobuccal root of the maxillary second molar had the highest rate of protrusion into the maxillary sinus floor. Many studies have assessed the relationship between the maxillary sinus and roots using various criteria. Several studies have evaluated the roots of maxillary teeth according to 4 types: no touching (type 0), touching the cortical borders of the sinus (type 1), projecting laterally along the sinus cavity (type 2), and protruding into the sinus (type 3).<sup>12,13</sup>

The panoramic radiography is the most common diagnostic aid used to assess the proximity between maxillary posterior roots and the maxillary sinus, but assessments of relationship between the upper dental roots and the maxillary sinus showed that panoramic radiography and CT scans differ significantly.<sup>14,15,16</sup>

Studies have shown that the accuracy of the CBCT imaging for bone measurement around the apices of the posterior teeth is valid and provide great advantage in obtaining data on a non-invasive form, revealing high predisposition to CBCT of 0.4 mm with a standard deviation of 1.1 mm when compared with dissections.<sup>17</sup>

In the present study, CBCT images showed that 37 teeth (14.8%) penetrated into the maxillary sinus cavity, whereas 93 (37.2%) were at a discernible distance from the maxillary sinus floor. Even though the panoramic radiograph showed high concordance when the roots were below the maxillary sinus floor, there was a percentage of roots that was on the limit or beyond the maxillary sinus floor, approximately 40%. These results corroborate with those of another study<sup>16</sup>, according to which when there is a percentage of 36% of teeth that are on the limit or beyond the maxillary sinus floor, CBCT should be used as the imaging modality suitable for such evaluations. In addition, Jung et al. (2012)<sup>4</sup> reported a percentage of 41.2 of first and second molars on the limit or beyond the maxillary sinus floor.

Previous studies have reported good agreement for roots that were not in contact with the maxillary sinus floor on panoramic radiographs and CT or CBCT images.<sup>7,11</sup>

Lopes et al.<sup>11</sup> reported 5 panoramic signs of root protrusion into the maxillary sinus, as follows: projection of the root apices, interruption of the maxillary sinus floor, absence of the lamina dura, darkening of the root apices, and a superiorly curving sinus floor enveloping the associated tooth root. They found that the projection of the root into the sinus and the interruption of the cortex of the maxillary sinus floor were statistically relevant indicators. Themkumkwun et al.<sup>12</sup> modified one of the panoramic radiographic signs by investigating the periodontal ligament space instead of evaluating the lamina dura due to the difficulty of identifying the radiopaque line of the lamina dura on panoramic images. In another study, CT showed that roots were lateral to the sinus cavity in 7 out of 30 cases, whereas on panoramic radiograph suggested that roots penetrated the maxillary sinus floor.<sup>18</sup>

A limitation in this study is the lack of analysis of histological samples. Since the oral radiologists evaluating the CBCT images were free to deal with the software and there were no standardized tests in reading the CBCT, they simply chose the window with better visualization of the apices in relation to the maxillary sinus floor.

## CONCLUSION

In conclusion, although panoramic radiography does not allow for a precise determination of the topographic relationship between posterior teeth and the maxillary sinus, radiographic signs such as root projection onto the sinus cavity and discontinuities of the sinus floor

suggest that roots may be protruding into the maxillary sinus. When surgeons find themselves in doubt in the face of these radiographic signs, asking for CBCT scans in the pre-operative work-up of the posterior maxilla is justified.

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