Original Article

Morphometric analysis of the relationship between maxillary posterior teeth and maxillary sinus floor in central Indian population: A cone-beam computed tomography study

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Abstract

Background: The relationship between the maxillary sinus (MS) and the root apices of posterior teeth is of significant clinical relevance as it influences the diagnosis and treatment planning when operating in the posterior areas of the maxilla. The aim of this study, therefore, is to assess this anatomic relationship and evaluate the propensity of roots of posterior maxillary teeth to be intruded into the MS space using cone-beam computed tomography (CBCT) scanning.

Materials and Methods: One thousand CBCT scans of patients, aged 20 years or above, were analyzed in the study. The distance from the MS floor to the root apices of the posterior teeth was measured and the relationship between the MS and the posterior teeth roots were recorded, based on Kwak's and Didilescu's classification.

Results: Based on Kwak's classification, type I configuration was frequently observed in the maxillary posterior teeth, followed by type II. Based on Didilescu's classification, the longest distance, among premolars, was observed between the palatal root of the left 1st premolar and MS, i.e., 8.2467 mm. Among molars, the longest distance was observed between mesiobuccal root of the right first molar and MS, i.e., 5.8966 mm. The shortest distance, among premolars, was observed between the buccal root of the left second premolar and MS, i.e., 3.5500 mm, and among molars, the shortest distance was between the mesiobuccal root of the left second molar and MS, i.e., 1.3556 mm.

Conclusion: From the present study, it may be concluded that, among the central Indian population, mesiobuccal root of the second molars and buccal root of the second premolars show the closest proximity to the MS floor. Therefore, any surgical or endodontic intervention in the vicinity of these roots must be performed with utmost care.

Keywords: Cone-beam computed tomography; maxillary molars; maxillary premolars; maxillary sinus and root apices

INTRODUCTION

The maxillary sinus (MS) is the largest pyramid-shaped bilateral air sinus situated within the maxilla,[1] and they are two of the four paired sets of the paranasal sinuses that are first to develop in fetal life.[2] The floor of the MS is formed by the alveolar and palatine processes of the maxilla and is lined by a thin mucosal membrane over the cortical bone. The volume of the MS cavity is variable and dynamic with its floor at the same horizontal level as the nasal floor at 12 years of age which drops somewhat below

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the level of the nasal cavity with the eruption of the upper third molar.[3] An intimate relationship exists between the root tips of maxillary posterior teeth and the sinus floor. Hence, any surgical intervention or odontogenic infection in relation to maxillary posterior teeth may allow bacteria from infected periapical tissues, resected root tips, or bony drilling to be displaced into the sinus which may be responsible for 10%–12% cases of maxillary sinusitis.[4,5] In addition, inadvertent overinstrumentation or overfilling during root canal therapy may lead to the ingress of foreign materials into the MS, which may result in maxillary sinusitis of endodontic origin.

Cone-beam computed tomography (CBCT), an advanced three-dimensional imaging technology, plays a crucial role in dentistry, particularly in endodontics. It proves invaluable for diagnosis, treatment planning, and various procedures, thus enhancing precision and efficacy in dental care.[6-9]

Understanding the interconnection among the roots of maxillary posterior teeth and the floor of MS is of prime significance and has been broadly studied in populations of Saudi Arabia,[10] China,[11] Bulgaria,[12] and Iran.[13] However, no such study has been previously conducted in the Indian population, especially in the central Indian population.

The aim of this study, therefore, was to assess this anatomic relationship, which is important when dealing with intervention near the roots of maxillary posterior teeth. The segregation of the accumulated data based on two modern classifications may serve as a simplified tool, which may be relevant to clinicians while performing any procedures to the maxillary posterior teeth.

MATERIALS AND METHODS

The retrospective observational study was conducted on CBCT scans made obtainable from diverse diagnostic centers in central India, and the dataset was anonymized to ensure patient confidentiality. Scans included those taken for diagnostic purposes such as diagnosis of radiolucent lesions, treatment planning for implant placement, assessment of relationships of teeth with clinically important anatomical structures, and for planning of maxillofacial surgery. The inclusion criteria comprised scans obtained from a sample population from central India, where the age of the individuals was 20 years or more, teeth without any apical resorption, or pathologies in the area of study, with no history of orthodontic treatment or any surgical procedures involving the MS. Scans with inadequate picture quality with artifacts caused by osteosynthesis plates, implants, or movement of the patient during exposure were excluded. Teeth with open apices, supernumerary teeth, and any other aberrant morphology were also excluded from the study. The study was conducted in accordance with the rules of ethics Declared by Helsinki, and ethical clearance was obtained from the Institutional Ethical Committee (Ref No.IEC/2022/177E).

To evaluate the relationship of maxillary posterior teeth to the MS, sample size calculation was done using G*Power software which revealed that a minimum of 596 CBCT scans were required to detect a statistical difference of around 0.01 mm in the mean value.

This same minimal sample size was also required to measure the distance between the MS and the anatomic apex of the maxillary posterior teeth at an alpha of 0.05 with a power of 80%. Therefore, to fulfill these requirements, the sample size selected was 1000 CBCT scans which included both right and left upper quadrant images.

All CBCT scans were performed using field of view (FOV): 8 × 12, KVP 90, mA 6 with a voxel size of 0.125–0.25 mm, and an exposure time of 16 s. The images were studied using the NNT viewer software program (NNT software corporation, Yokohama, Japan) and evaluated by two observers, one radiologist, and one endodontist. The interrater reliability between the observers upon the images was found to be high because of superior image quality, standardization of all exposure factors, and adequate experience of the two observers in the field of oral radiology. Measurements were performed using axial, sagittal, and coronal CBCT slices of different thicknesses.

The study data were compiled based on the following two classifications:

1. Vertical relationship between MS and apices of posterior teeth based on Kwak's *et al*.'s classification: [Figure 1][14]
    - Type I: The inferior wall of the MS floor is located above the root apex of the buccal and palatal root
    - Type II: The inferior wall of the MS is located below the level connecting the buccal and palatal root apices without an apical protrusion over the MS
    - Type III: Apical protrusion of the buccal root apex is observed over the inferior wall of the MS
    - Type IV: Apical protrusion of the palatal root apex is observed over the inferior wall of the MS
    - Type V: Apical protrusions of the buccal and palatal root apices are observed over the inferior wall of the MS.

For single-rooted teeth, the classification of the vertical relationship was used as follows: [Figure 2]

- Type I: The inferior wall of the MS floor is located above the root apex
- Type II: The root apex touches the inferior wall of the MS

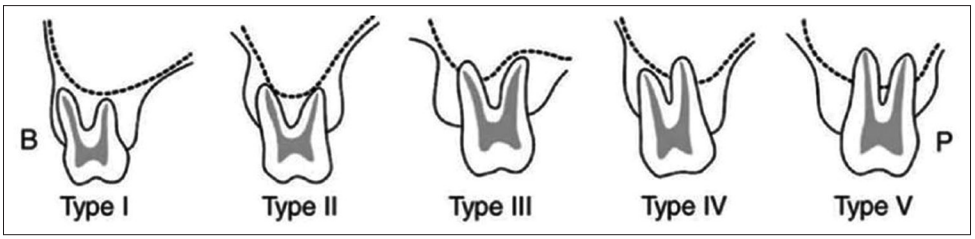

Figure 1: Vertical relationship between maxillary sinus and apices of multirooted teeth based of Kwak's classification

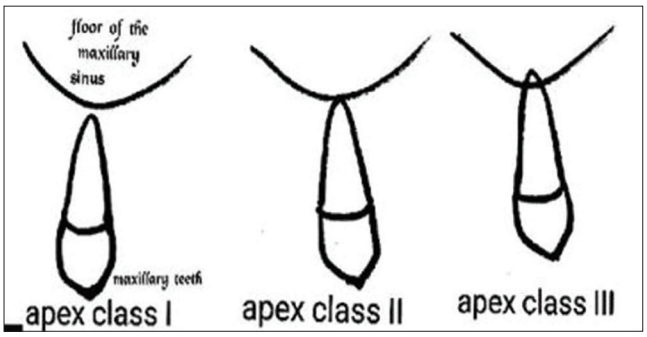

Figure 2: Vertical relationship between maxillary sinus and apices of single rooted teeth based of Kwak's classification

- Type III: Apical protrusion of the root apex is observed over the inferior wall of the MS.

2. Vertical distance between MS and the radiographic apex of the maxillary posterior teeth based on Didilescu's classification 1996:[15]
   - Distances 0, 0–2, 2–4, 4–6, and >6 mm were classified into four categories
   - Type 0: 0 mm (high-risk group)
   - Type 1: 0–2 mm distance between teeth and sinus (risky group)
   - Type 2: 2–4 mm distance between teeth and sinus (less risky group)
   - Type 3: 4–6 mm distance between teeth and sinus (nonrisky group)
   - Type 4: >6 mm distance between teeth and sinus (nonrisky group).

Statistical analysis

Data were analyzed using SPSS (Statistical Package for the Social Sciences) 21.0 version (IBM, Chicago, USA) for probability distribution using the Shapiro–Wilk test. Comparison of continuous variables between the right and left sides was done using the Independent *t*-test/Mann–Whitney *U*-test. A comparison of categorical variables was done using the Chi-square test. $P < 0.05$ was considered statistically significant. Confidence interval was set at 95%.

RESULTS

Among premolars, the longest distance was observed between the palatal root of the left first premolar and MS, i.e., 8.2467 mm (type IVs) and the shortest distance was observed between the buccal root of the left second premolar and MS, i.e., 3.5500 mm (type II) [Tables 1 and 2].

Among molars, the longest distance was observed between the mesiobuccal root of the right first molar and MS, i.e., 5.8966 mm (type III), and the shortest distance was observed between the mesiobuccal root of the left second molar and MS, i.e., 1.3556 mm (type I).

DISCUSSION

A thorough understanding of the proximity of the maxillary posterior teeth to the MS is crucial not only for performing surgical procedures such as tooth extraction, implant placement, and sinus lifting but also for recognizing the potential for pulpal remnants and obturating materials to be pushed into the MS during root canal treatment, as well as the risks involved during orthodontic movement of the posterior teeth, especially tooth intrusion. This understanding is important to alert the clinicians about the probability of unpleasant consequences of oroantral communication, thus allowing him/her to take all the necessary precautions before performing any invasive procedures in the maxillary posterior tooth region.

The result of the present study, based on Kwak's classification, revealed that type I relation was the most commonly observed relation in both maxillary premolars and molars. The second-most common configuration with premolars was type II, where the inferior wall of the MS is located below the level connecting the buccal and palatal root apices, without any apical protrusion into the MS. For maxillary molars, type III configuration, i.e., protrusion of the buccal root apex beyond the inferior wall of the MS, was most prevalent.

In a similar study, Haghanifar *et al*.[16] categorized the sinus-root correlation in the sample Iranian population. They reported that from a total of 419 maxillary molars, 23.9% were located outside the sinus and demonstrated, i.e., type I configuration, whereas, the current study reported that 93.9% of premolars and 71.9% of molars presented type I relationship. Haghanifar *et al*.[16] revealed that in 66.6% of cases, there was contact of root apices with the sinus floor, i.e., type II relationship, which is in contrast to the current study, where only around 6% of premolars

Table 1: Distribution of teeth based on vertical relationship between root apices of maxillary premolars and molars with maxillary sinus based on Kwak's classification

	Type I, *n* (%)	Type II, *n* (%)	Type III, *n* (%)	Type IV, *n* (%)	Type V, *n* (%)
Right first premolar (*n*=244)	244 (100)	0	0	0	0
Left first premolar (*n*=252)	236 (93.6)	16 (6.3)	0	0	0
Right second premolar (*n*=188)	164 (87.2)	24 (12.7)	0	0	0
Left second premolar (*n*=248)	232 (93.5)	16 (6.4)	0	0	0
Mean percentage values considering all premolars	93.9	6	0	0	0
Right first molar (*n*=232)	192 (82.7)	0	40 (17.2)	0	0
Left first molar (*n*=296)	192 (64.8)	32 (10.8)	32 (10.8)	16 (5.4)	24 (8.1)
Right second molar (*n*=240)	168 (70)	12 (5)	0	0	60 (25)
Left second molar (*n*=216)	156 (72.2)	12 (5.5)	48 (22.2)	0	0
Mean percentage values considering all molars	71.9	5.7	12.1	1.6	8.5

Table 2: Distance of right and left maxillary premolars and molars from the floor of the maxillary sinus, based on Didilescu's classification

	Mean (mm)	SD	95% CI for mean	Minimum	Maximum
Right first premolar					
Buccal root	6.6869 (type IV)	2.91762	5.9396–7.4341	1.20	12.80
Palatal root	6.1180 (type IV)	2.67641	5.4326–6.8035	1.30	10.40
Left first premolar					
Buccal root	6.5190 (type IV)	2.85831	5.7992–7.2389	0.00	10.50
Palatal root	8.2467 (type IV)	4.96146	6.9650–9.5283	0.00	27.00
Right second premolar					
Buccal root	4.4638 (type III)	3.30391	3.4938–5.4339	0.00	11.80
Palatal root	4.2085 (type III)	3.41893	3.2047–5.2123	0.00	15.20
Left second premolar					
Buccal root	3.5500 (type II)	2.61952	2.8848–4.2152	0.00	11.20
Palatal root	3.6754 (type II)	3.17143	2.8339–4.5169	0.00	11.20
Right first molar					
Mesiobuccal root	5.8966 (type III)	4.08687	4.3420–7.4511	1.20	14.30
Distobuccal root	5.0714 (type III)	3.50530	3.4758–6.6670	0.00	12.10
Palatal root	5.0379 (type III)	5.10822	3.0949–6.9810	−4.40	14.80
Left first molar					
Mesiobuccal root	2.2270	2.60924	1.3572–3.0970	−2.20	7.90
Distobuccal root	2.4438	3.76109	1.0877–3.7998	−3.90	8.20
Palatal root	2.5676	3.14193	1.5200–3.6151	−1.80	10.20
Right second molar					
Mesiobuccal root	5.1150	4.98284	2.7830–7.4470	−6.50	14.30
Distobuccal root	2.8538	6.05456	−0.8049–6.5126	−8.80	14.30
Palatal root	4.5200	3.83263	2.7263–6.3137	−2.00	14.00
Left second premolar					
Mesiobuccal root	1.3556	1.53440	0.5925–2.1186	−0.90	4.70
Distobuccal root	2.6059	4.05778	0.5196–4.6922	−1.80	12.50
Palatal root	4.7222	3.85129	2.8070–6.6374	0.00	14.40

SD: Standard deviation, CI: Confidence interval

and 5.6% of molars presented the type II configuration. 9.5% of molars protruded into the sinus (type III, type IV, and type V) in the sample Iranian population which represents a relatively higher percentage when compared to the current study, where only 1.6% presented with type III, type IV, and type V configurations. This obvious discrepancy between the two studies may be ascribed to the difference in population demography and sample size.

Based on Didilescu's classification, in the present study, the individual root with the highest probability of intrusion into the MS is the mesiobuccal root of the left second molar which showed type I relationship with a mean distance of 1.3556 mm depicting the highest risk of the sinus invasion during any intervention. Among the premolars, the buccal root of the left second premolar presented type II relationship with the sinus with an average distance of 3.550 mm, thus warranting caution during performing any procedure in the region. This is in compliance with a study by Tang *et al*.[17] which agreed that the mesiobuccal root of the maxillary second molars is the closest to the MS floor among all the teeth in the maxillary arch. The outcome of the present study is, however, in contrast to a study conducted by Georgiev *et al*.[12] which stated that the distobuccal root of the maxillary second molar is the closest to the MS floor posing the highest risk of oroantral communication. Other studies by Didilescue *et al*.[15] and Kaushik *et al*.[18] concluded that the roots of the maxillary first molar present the closest proximity to the MS floor.

In this study, the longest mean distance from the MS to the root apices was observed for the palatal root of the

left first premolars with an average distance of 8.2467 mm and mesiobuccal root of the right first molars with an average distance of 5.8966 mm, thus rendering them risk free to work on. A study by Kilic *et al*.[19] revealed similar results with the distance between the sinus floor and root tip being the longest for the maxillary first premolars and shortest for the distobuccal root of the second molar.

Based on the findings of the present study, it may be stated that the classification suggested by Didilescu is more detailed, comprehensive, and conclusive, thus providing a suitable evaluation of the root-sinus relationship, when compared to the classification proposed by Kwak.

Familiarity with this relationship can guide clinicians in preparing an optimal treatment plan which may help to avoid any accidental encroachment into the sinus space during surgical and endodontic procedures.

Limitations of this study, however, include the relatively small sample size and the fact that variations based on gender have not been taken into consideration in the present study.

CONCLUSION

Within the limitations of the present study, it may be concluded that there is considerable variation in the sinus root relationship based on ethnicity.

In the central Indian population, among the roots of the maxillary posterior teeth, the mesiobuccal root of the second molars and the buccal root of the second premolars show the closest proximity to the MS floor. Therefore, any surgical or endodontic intervention in the vicinity of these roots must be performed with utmost care.

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Conflicts of interest

There are no conflicts of interest.

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