Original Article

A Retrospective Study on the Relationship between Maxillary Posterior Teeth and Maxillary Sinus Floor Using Cone-beam Computed Tomographic Images

Lijie Tang, Laiqing Xu, Hongchen Liu

Department of VIP Clinic, Beijing Stomatological Hospital, Capital Medical University, Institution of Stomatology, Chinese PLA General Hospital, Beijing, China

Abstract

Introduction: The aims of this study were to evaluate the distance and relationship between the root apex of maxillary posterior teeth and the maxillary sinus floor (MSF) and whether they varied with age. Cone-beam computed tomographic (CBCT) images covering maxillary sinus taken in our department from December 2015 to December 2016 were retrospectively analyzed. **Material and Methods:** Totally 221 CBCT images of maxillary posterior teeth were analyzed. The distance and relationship between the root apex and the MSF was measured and categorized into four types. The data were correlated with age. ANOVA, Fisher's exact test, Cochran–Armitage trend test, Pearson's Chi-square test were used. **Results:** For the second premolar, the distance from the apex to the MSF was the furthest compared to first and second molars. The majority of apices were located below the MSF. For the first molar, the palatal root owned the shortest distance (2.79 mm) ($P < 0.05$) and highest frequency (11.8%) in Type IV (root protruded into the MSF) in all teeth. For second molar, the mesiobuccal root had the minimum distance (2.08 mm) ($P < 0.05$) in all teeth and the second highest frequency (11.0%) in Type IV. In young people (20–40 years), the shorter distance and higher frequency in Type IV differed significantly compared to other age groups ($P < 0.05$). **Discussion and Conclusion:** The data verified the close relationship between the root apex of maxillary posterior teeth and the MSF. Age was a key factor to correlate the relation. Special care should be taken when dealing with maxillary posterior teeth, especially for young people.

Keywords: *Cone-beam computed tomography, maxillary molars, maxillary premolars, maxillary sinus*

Introduction

The maxillary sinus (MS) is located in the midface, which has access to the alveolar process downward and is of great significant when conducting treatment on maxillary posterior teeth such as root canal therapy, tooth extraction, and implantation.[1] When the roots are so close to the MS floor (MSF), there may also be an access for bacteria from infected periapical tissue to entering the MS which has the possibility to develop acute or chronic maxillary sinusitis.[2] The aim of the present study is to investigate the relationship between MSF and maxillary posterior teeth and to analyze its correlation with age.

Material and Methods

Cone-beam computed tomographic (CBCT) images covering MS taken in our department from December 2015 to December 2016 were retrospectively analyzed. The study was approved by the Chinese Ethics Committee of Registering Clinical Trials (reference number: ChiECRCT-20190009) and carried out in accordance with the Declaration of Helsinki.

Images presenting with the following findings were included in further analysis: (1) Maxillary permanent second premolars with single root, maxillary permanent first and second molars with three roots, all of which were referred to the "posterior teeth" in this paper, (2) patients at least 21 years of age[3] with fully erupted teeth and fully formed apices, (3) maxillary premolars and molars with neither severely endodontic or periapical disease nor periodontal disease, and (4) maxillary posterior teeth alignment appears basically normal without overcrowding or dislocated.

How to cite this article: Tang L, Xu L, Liu H. A retrospective study on the relationship between maxillary posterior teeth and maxillary sinus floor using cone-beam computed tomographic images. J Anat Soc India 2020;68:253-9.

Article Info

Received: 19 June 2019
Accepted: 16 January 2020
Available online: 28 February 2020

Address for correspondence:
Dr. Hongchen Liu,
Rd Fuxing No. 28,
Beijing 100853, China.
E-mail: liu-hc301@hotmail.com

Access this article online

Website: www.jasi.org.in
DOI: 10.4103/JASI.JASI_81_19
Quick Response Code:

Images presenting with the following findings were excluded from the study: (1) MS had surgical history, i.e., sinus floor elevation, (2) teeth had previously undergone orthodontic treatment, and (3) images with low quality resulting from artifacts caused by motion or high-density objects.

The CBCT images were obtained with NewTom 5G (Quantitative Radiology s. r. l., Verona, Italy) at 110 KV, 1–20 mA, and exposure time varying between 3.6 s and 7.3 s, with voxel size of 0.150 mm/0.300 mm, F. O. V (D×H) varying from 6 cm × 6 cm to 18 cm × 16 cm. The axial slices were reconstructed with the thickness of 0.150 mm or 0.300 mm, which were positioned parallel to the Frankfort plane. The measurements of each root were made on both the sagittal and coronal planes through the central long axis of each tooth.[4-6] All CBCT images were evaluated with NewTom 5G free software NNT viewer and the following analyses and measurements were performed:

1. The shortest distance (vertical/oblique) between the root apex of the posterior teeth and the border of the MSF was measured in CBCT sagittal and coronal planes, and the minimum value was recorded [Figure 1]. If the root apex protruded into the sinus, a negative value was recorded
2. The vertical relationship between the root apex of the posterior teeth and the MSF was divided into four types both in CBCT sagittal and coronal planes according to the image observation and literature references[7-9] [Figure 2]:
   - Type I: Root apex located below/outside the MSF. Subtype Ia: Root apex located below the sinus floor in both vertical and horizontal directions [Figure 2a] and subtype Ib: Root apex located outside the sinus floor only in horizontal direction but above the lowest point of sinus floor in vertical direction [Figure 2b]
   - Type II: Root apex contacting with the MSF through a point or small area. Subtype IIa: Root apex contacting with the sinus floor through a point or small area in both vertical and horizontal direction which means the root apex located at the lowest point of MSF [Figure 2c] and subtype IIb: Root apex contacting with the sinus floor through a point or small area only in horizontal direction but above the lowest point of sinus floor in vertical direction [Figure 2d]
   - Type III: Part of root contacting with the MSF. Subtype IIIa: Part of root with root apex contacting with the sinus floor [Figure 2e]. Subtype IIIb: Part of root without root apex contacting with the sinus floor [Figure 2f]
   - Type IV: Part of root with root apex protruding into the sinus both in vertical and horizontal directions [Figure 2g].

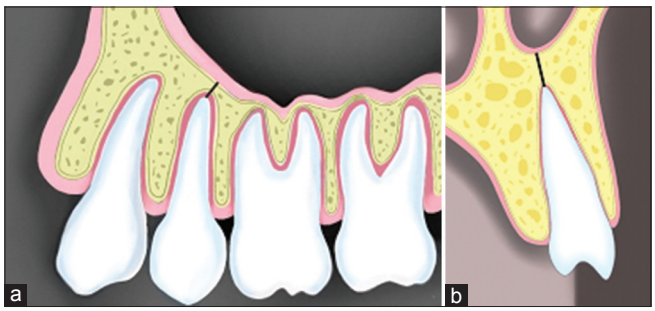

Figure 1: Measurement of shortest distance between root apex and maxillary sinus floor in sagittal (a) and coronal (b) plane

The basis of our classification was according to the proximity between the root apex and the MSF. The closer distance to the MSF, the greater possibility to cause odontogenic oroantral complications, and the higher rank the root belonged to. Thus, we defined the Type IV was the top priority one and Type III, II, and I was in sequence. For the subtype, we determined that subtype b was prior to subtype a. Because for subtype b, their adjacent teeth may have a closer relationship with MSF, whereas subtype a not. For example, the observed root belonged to subtype IIa (the root apex contacted with the MSF both on the horizontal and vertical directions on CBCT images), which meant that this root was located at the lowest point of MSF. However, for the root belonged to subtype IIb (the root apex contacted with the MSF only in horizontal direction, but was above the lowest point of MSF in vertical direction), the observed root contacted with the lateral wall of MSF, not located at the lowest point, which meant that its adjacent tooth had the possibility to have a closer relation with MSF even protrude into it. It was the same to subtype Ia/Ib and IIIa/IIIb. Thus, we ranked the subtype b prior to subtype a. Hence, the priority order of the four types (seven subtypes) was Type IV > Type III (subtype IIIb > subtype IIIa) > Type II (subtype IIb > subtype IIa) > Type I (subtype Ib > subtype Ia). If CBCT images of a root showed different position relationship to sinus floor in sagittal and coronal planes, the prior type/subtype was recorded.

All CBCT images were reviewed twice at an interval of 2 weeks by one reader. After standard conformance testing, the kappa value was 0.782 and the mean measurement value was recorded. In addition, the age, gender, and side of each patient were recorded to correlate these data. Age was divided into three groups: 21–40 years, 41–60 years, and ≥61 years.

Statistical analysis was processed by software SAS 9.2 (SAS Institute Inc., Cary, NC, USA). All data were performed a descriptive analysis with the amount and percentage of the findings. For measurement data, ANOVA and Fisher's exact test were used to study the distance between the root apex and the MSF regarding different tooth type, age, gender, and side.[7] $P < 0.05$ was considered statistically significant. The Cochran–Armitage trend test was used to analyze the trend of the distance between the root apex and the MSF.

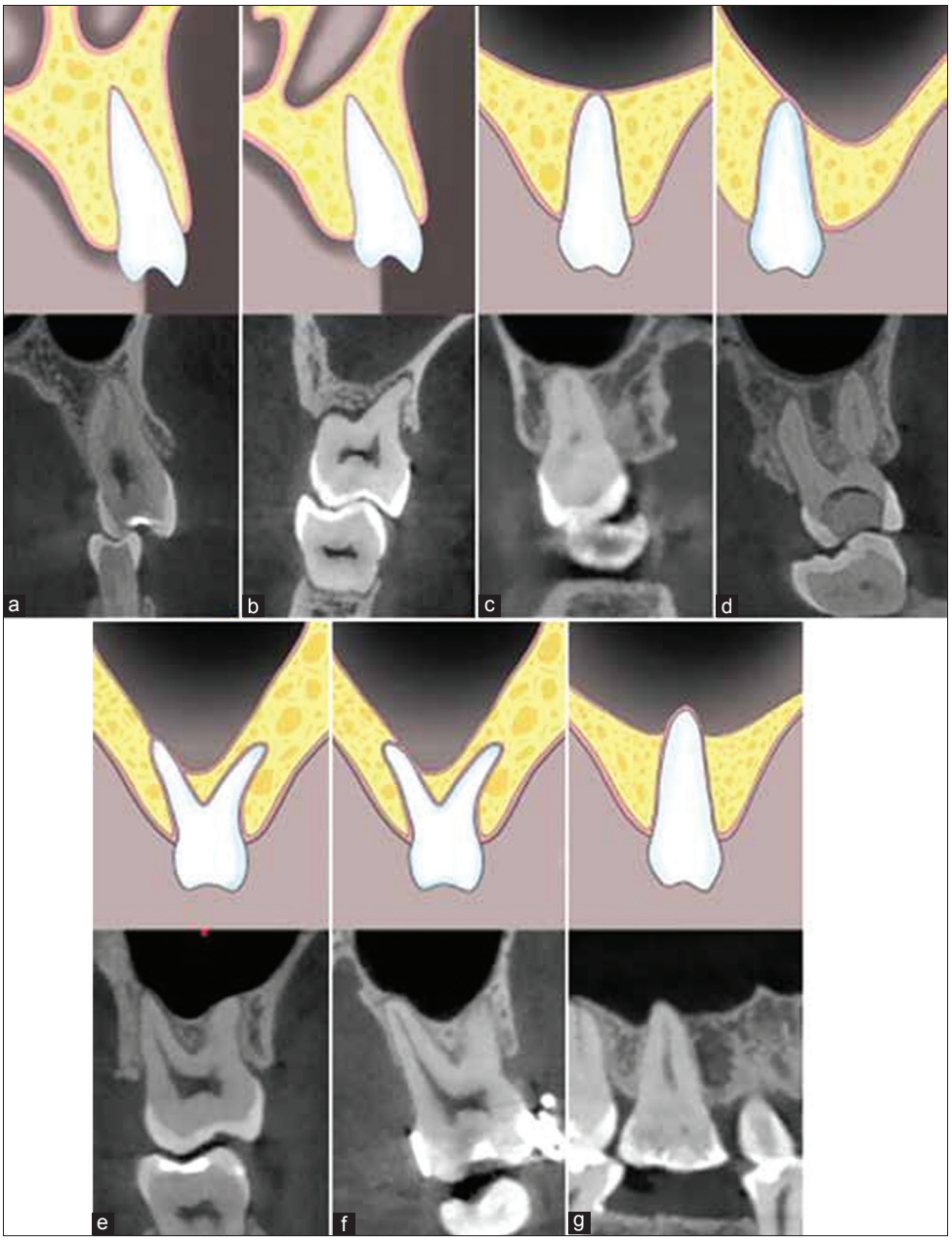

Figure 2: Vertical relationship of root apex and maxillary sinus floor. (a) Ia: Root apex located below the sinus floor in both vertical and horizontal direction. (b) Ib: Root apex located outside the sinus floor only in horizontal direction but above the lowest point of sinus floor in vertical direction, (c) IIa: Root apex contacting with the sinus floor through a point or small area in both vertical and horizontal directions. (d) IIb: Root apex contacting with the sinus floor through a point or small area only in horizontal direction but above the lowest point of sinus floor in vertical direction. (e) IIIa: Part of root with root apex contacting with the sinus floor. (f) IIIb: Part of root without root apex contacting with the sinus floor. (g) Part of root with root apex protruding into the sinus both in vertical and horizontal direction

For categorical data, Pearson's Chi-square test was used to study the distribution difference of the vertical relationship between the root apex and the MSF.

Results

Totally 221 patients were included in this study (males: 51.6%, females: 48.4%, age: 21–84 years, average 47.8 ± 13.9 years). A total of 316 sinuses, 618 teeth, and 1416 roots were analyzed, among which 219 were second premolar, 226 were first molar, and 173 were second molar.

The mean distance between the root apex and the maxillary sinus floor

For the second premolar, the mean distance from the root apex to the MSF was 4.15 ± 3.85 mm. For the first molar, the mean distances for mesial buccal root (6MB), distal buccal root (6DB), and palatal root (6P) were 3.69 ± 3.71 mm, 3.61 ± 3.73 mm, and 2.79 ± 3.86 mm, respectively. For 6MB versus 6P and 6DB versus 6P, $P < 0.05$, and for 6MB versus 6DB, $P > 0.05$. For the second molar, the

mean distances for mesial buccal root (7MB), distal buccal root (7DB), and palatal root (7P) were 2.08 ± 3.46 mm, 3.04 ± 3.77 mm, and 3.64 ± 3.76 mm, respectively. For 7MB versus 7DB and 7MB versus 7P, $P < 0.05$, and for 7DB versus 7P, $P > 0.05$.

The relationship between the root apex and the maxillary sinus floor

For the maxillary first molar, the highest percentage of root protruding into the sinus was in palatal root (6P), 11.8%, which was also the highest among all roots. The corresponding percentage in mesiobuccal (6MB) and distobuccal (6DB) root was 3.5% and 2.6%, respectively. Similar to the second premolar, the frequency for type I, which was away from MSF, was the highest though a little lower than the second premolar (the value of 6MB, 6DB, and 6P was 84.2%, 79.4%, and 67.1%, respectively). The highest rate for the root contacting with MSF (Type II + Type III) was in 6DB (14.0% and 11.0%, respectively, totally 25%). The rate for close relation between the root and MSF (Type II + Type III + Type IV) was in 6P (32.9%), which was significantly higher than 6MB and 6DB ($P < 0.05$) [Table 1]. It prompted that the palatal root of the first molar was more inclined to have complications of oroantral fistula when carried out the tooth extraction or root canal therapy.

The second molar and maxillary sinus floor

For the maxillary second molar, the rate of type IV was high in both 7MB and 7DB, which was 11.0% and 8.1%, respectively. Compared with 6P, only 4% of 7P was protruding into sinus ($P < 0.05$). Through Cochran–Armitage trend test analysis, the results showed that the second premolar, the first molar, and the second molar had the trend to be closer toward MS. Considering that the distance between the 7MB and MSF was the shortest, it can be suggested that the lowest point of MS was located near the 7MB or somewhere between the first and second molars.

In addition, there was a very interesting result that if one root belonged to Type III other roots were very likely belonging to Type IV for maxillary first molar (using Cochran–Armitage trend test analysis, $P < 0.05$). Similarly, for the maxillary second molar, when mesiobuccal root was in Type III, the rate for distobuccal and palatal root presenting Type IV was obviously increased ($P < 0.05$).

The influence of age on the mean distance between the root and maxillary sinus floor

According to different age groups, the results showed that the mean distance from the root apex to the MSF under 40 years old was significantly less than that over 40 years old ($P < 0.05$). However, the corresponding mean distance for whom over 40 years old had no significant difference [Figure 3]. Moreover, the distance between 7MB and MSF was the shortest in all age groups and had statistical significance ($P < 0.05$). The percentage of the root protruding into the sinus (Type IV) decreased with age increasing [Table 2 and Figure 4]. In the 21–40 years' age group, significant differences in the frequency of Type IV were found when compared to other age groups ($P < 0.05$).

The influence of gender and side on the mean distance from the root apex to the maxillary sinus floor

Using ANOVA to analyze the influence of gender and side on the mean distance from the root apex to the MSF, the results showed that there was no statistical difference ($P > 0.05$), which meant that gender and side had no effects on the mean distance from the root apex to the MSF.

Discussion

Anatomically, the MSF covers roots apex from maxillary second premolar to third molar. It is often seen as a thin plate of bone between the MSF and roots apex even though at times there is no bone but only a mucosa lining.[10,11] The proximity may cause periapical periodontitis spreading into MS directly and further cause sinus infection.[12] Some iatrogenic factors may also affect MS for the close relation between maxillary teeth and sinus. For example, during the root canal therapy, it is easy to push out some debris or filling materials into the MS which leads to sinus inflammation.[13] During the tooth extraction process, the

Table 1: The relationship between maxillary posterior teeth and maxillary sinus floor

Root	Quantity/ratio (%)									
	I			II			III			IV
	Ia	Ib	Total	IIa	IIb	Total	IIIa	IIIb	Total	
5[#a]	200/79.4	19/7.5	219/86.9	5/2.0	3/1.2	8/3.2	17/6.7	5/2.0	22/8.7	3/1.2
6MB[b]	172/75.4	20/8.8	192/84.2	7/3.1	4/1.8	11/4.8	13/5.7	4/1.8	17/7.5	8/3.5
6DB[c]	167/73.2	14/6.1	181/79.4	8/3.5	24/10.5	32/14.0	24/10.5	1/0.4	25/11.0	6/2.6
6P[d]	139/61.0	14/6.1	153/67.1	4/1.8	9/3.9	13/5.7	30/13.2	5/2.2	35/15.4	27/11.8
7MB[e]	105/60.7	14/8.1	119/68.8	14/8.1	8/4.6	22/12.7	15/8.7	1/0.6	16/9.2	19/11.0
7DB[f]	115/66.5	14/8.1	129/74.6	9/5.2	11/6.4	20/11.6	9/5.2	1/0.6	10/5.8	14/8.1
7P[g]	125/72.3	18/10.4	143/82.7	6/3.5	9/5.2	15/8.7	6/3.5	2/1.2	8/4.6	7/4.0

[a,#]5: Maxillary second premolar, [b]6MB: Mesiobuccal root of maxillary first molar, [c]6DB: Distobuccal root of maxillary first molar, [d]6P: Palatal root of maxillary first molar, [e]7MB: Mesiobuccal root of maxillary second molar, [f]7DB: Distobuccal root of maxillary second molar, [g]7P: Palatal root of maxillary second molar

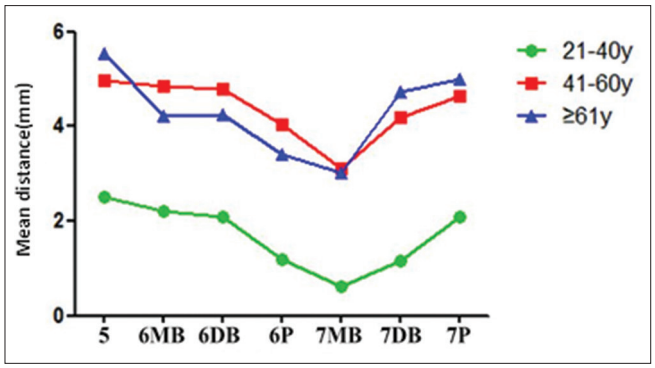

Figure 3: Mean distance between the root apex and the maxillary sinus floor for different age groups

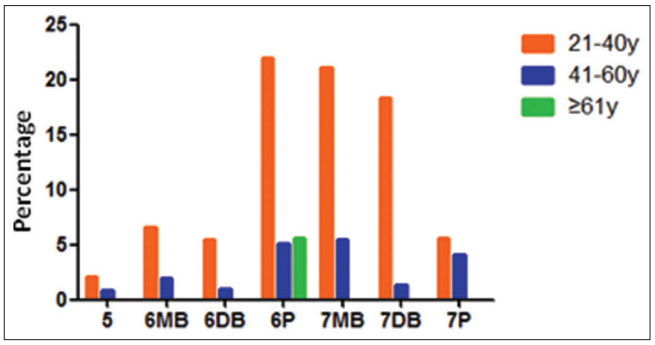

Figure 4: Percentage of Type IV in different age groups

Table 2: The proportion of root for Type IV referring to age

	Quantity/ratio (%)			
	21-40 years	41-60 years	>61 years	Total
5[#a]	2/2.1	1/0.9	0/0	3/1.2
6MB[b]	6/3.9	2/2.0	0/0	8/3.5
6DB[c]	5/5.5	1/1.0	0/0	6/2.6
6P[d]	20/22.0	5/5.0	2/5.4	27/11.8
7MB[e]	15/21.1	4/5.5	0/0	19/11.0
7DB[f]	13/18.3	1/1.4	0/0	14/8.1
7P[g]	4/5.6	3/4.1	0/0	7/4.0

[a,#]5: Maxillary second premolar, [b]6MB: Mesiobuccal root of maxillary first molar, [c]6DB: Distobuccal root of maxillary first molar, [d]6P: Palatal root of maxillary first molar, [e]7MB: Mesiobuccal root of maxillary second molar, [f]7DB: Distobuccal root of maxillary second molar, [g]7P: Palatal root of maxillary second molar

mucosa lining on the MSF may be avulsed, which causes mucosa perforation or oroantral fistula[14,15] when the tooth becomes dislocated. In such conditions, the root or other foreign material may be pushed into the sinus.[16,17]

CBCT as a noninvasive examination method provides an accurate three-dimensional evaluation of maxillofacial bony structures' anatomical relationship.[18] CBCT with high resolution allows clinicians to observe structures from all angles by about 1-mm slice thickness. For some subtle structures, i.e., minor septa on MSF or thin-layer bone plate between the root apex and the MSF, CBCT has better resolution capability compared to other radiological methods.[19,20] It can also identify mucous tissue lining on the MSF, which is <2 mm thick.[21] Consequently, it is quite feasible to study the relationship between the root apex and the MSF by CBCT.

It was found that the classification of the relationship between maxillary posterior teeth and MSF was incomplete by reviewing literatures. Some researchers[22,23] only made the classification into three types: away from, contacting with, and protruding into the sinus. Pagin *et al*.[3] only studied the contacting type and detailed them into contacting by a point or an area. However, none of these studies have covered all the observable types of the relationship between the root apex and the MSF on CBCT images. After referring to previous literatures, we made this particular classification covering every observable situation in this research.

It is known that the relationship between the root apex and the MSF may reveal different images on coronal and sagittal CBCT planes. That is to say, a root may display to protrude into the sinus on one CBCT plane, but contact with even be away from the sinus floor on another CBCT plane. Several researchers have also reported this phenomenon.[22,24] Hence, they defined the protruding type to be the root that had shown the protrusion on all CBCT planes. However, even if there was only one plane that had shown the protrusion, there was a high risk for the root to cause odontogenic maxillary sinusitis. Therefore, if a root showed different classifications on different CBCT planes, the higher priority was recorded, which made it easier to predict the risk for complications. Similarly, some researchers also found that the mean distance between the root apex and the MSF was different on CBCT coronal and sagittal planes.[22,25,26] Therefore, to study the shortest distance between the root apex and the MSF, both coronal and sagittal CBCT planes were evaluated and the minimum value was selected as the final result in this study.

In the present study, the mean distance for the maxillary second premolar was 4.15 ± 3.85 mm; the value of 6MB, 6DB, and 6P was 3.69 ± 3.71 mm, 3.61 ± 3.73 mm, and 2.79 ± 3.86 mm, respectively, and for 7MB, 7DB, and 7P was 2.08 ± 3.46 mm, 3.04 ± 3.77 mm, and 3.64 ± 3.76 mm, respectively. It showed that the palatal root of the maxillary first molar and the mesiobuccal root of the maxillary second molar are in close contact with the MSF. Ananda *et al*.[27] reported that 71.7% MS extended downward into the multirooted tooth. Similarly, Kang *et al*.[24] reported that there were 94.3% MSF located between the maxillary first molar buccal and the palatal root and 81.1% MSF located between the maxillary second molar buccal and the palatal root. This may partially explain that the root of the first and second molars had the shorter distance to the MSF. Thus, for these first and second molars, after tooth extraction, it should be extremely careful to scale the socket in order not

to create an iatrogenic oroantral fistula. As we all know, the apical foramen will be enlarged if it suffered long term chronic periapical lesions. Especially for first and second molars, to avoid foreign bodies (i.e., root canal filling paste and gutta-percha) being pushed into the MS and bringing about odontogenic maxillary sinusitis, clinicians should be advised to use mineral trioxide aggregate (MTA) to seal these apical foramen before canal obturation when conducting root canal therapies.[28]

The results of this study were in good agreement with some studies,[26,29] which showed that mesiobuccal root of maxillary second molar had the shortest distance to the MSF. However, this result was not consistent with some other researches.[25,30] Their results showed that distobuccal root of the maxillary second molar had the shortest distance to the MSF. Analyzed the reasons for the difference: (a) all these researches did not share the same reference plane, which led to bias when measuring; (b) the experience and proficiency of different examiners may also bring about bias; and (c) the difference among different races and ethnicities may produce bias as well. However, generally speaking, the palatal root of maxillary first molar and buccal roots of maxillary second molar had closer relation with MSF, which was consistent with the present study.

For Type I, which root apex was located outside the MSF, regardless of in dental treatment or the spread of periapical infection, it was relatively safe and favorable for the protection of MS. Types II, III, and IV were more and more closely related to the MSF, especially the Type IV, whose root apex was protruded into MSF, had a greater possibility occurring odontogenic maxillary sinusitis and associated complications. Hence, before a Type IV tooth got treatment, the entirely preoperative examination and evaluation should be done and proper communication with patients should be given too. Meanwhile, it should be well prepared for dealing with any postoperative MS complications. In a previous study,[23] the percentage of Type IV was as high as 40%. However, the percentage in our study was only 11.8% at most (in 6P). The reason may be attributed to different resolutions of a CBCT machine. Because a root may show protruding into MS on a CBCT image with low resolution, it may be distinguished out a thin layer of bone between the root apex and the MSF on a CBCT image with high resolution. Because of the high percentage of protruding type and the short mean distance to MSF for the palatal root of maxillary first molar, this tooth was verified to have the highest incidence causing odontogenic maxillary sinusitis (22.51%).[11] Therefore, excessive wedged force should be avoided in case of pushing the root into MS when a Type IV maxillary first molar needs to be extracted. Moderate wedged force can be used for a root belonging to Type II or III, because there is a thin layer of bone between the root apex and the MSF. Evidently we do not recommend CBCT scanning as routine for its radiation exposure, but if a tooth is highly probable to be type IV and has the potential to cause troublesome complications , physicians should identify it by a limited-volume CBCT examination. To some extent, its advantages may outweigh the disadvantages for such cases.[31,32] In addition, CBCT could indicate us the access to the MS and evaluate the risk of the surgery if the undesirable complications really happened. Furthermore, CBCT would assist otolaryngologists to diagnose and make treatment plan if there was a need to cooperate with them further.

In terms of age, the results showed that the mean distance between the root apex and the MSF increased with age, and in all age groups, the root with shortest distance to MSF was 7MB. Moreover, the Type IV roots decreased with age, which was consistent with the result of Tian *et al*.[23] In the age group of 21–40 years, the percentage of 6P, 7MB, and 7DB was as high as 22.0%, 21.1%, and 18.3%, respectively, which suggested that there would be a high risk of odontogenic maxillary sinusitis or perforation of MSF for young people when performing treatment on maxillary first and second molars. Refer to this change with age, it may be speculated that the location of MSF and maxillary posterior root may move upward and downward with age increasing. This phenomenon may be explained by that the volume of MS had the tendency to decrease with age increasing.[33] The researchers found that the maximum volume of MS was between 20 and 30 years for women and 30 and 40 years for men. The larger the volume of MS, the shorter the distance between the root apex and the MSF. This conclusion also explained that the mean distance between the root apex and the MSF of age group of 21–40 years was the shortest. In addition, with the abrasion of occlusion surface of posterior teeth, the eruption of teeth toward occlusive surface with age further caused the distance between the root apex and the MS increasing. Because of the limitation of our experiment, further researches still require a larger and broader sample size.

Conclusions

1. The mean distance between the root apex of second premolar and the MSF was furthest and mesiobuccal root of second molar was nearest
2. It was rare for root protruding into MS in the second premolar, but common in the first molar palatal root and second molar buccal root
3. Age influenced the mean distance between the root apex and the MSF and the young were more likely to have roots protrusion into MS.

Financial support and sponsorship

This study was financially supported by Chinese Stomatological Association Youth Clinical Research Fund, No. CSA-B2018-10.

Conflicts of interest

There are no conflicts of interest.

References

1. Workman AD, Granquist EJ, Adappa ND. Odontogenic sinusitis: Developments in diagnosis, microbiology, and treatment. Curr Opin Otolaryngol Head Neck Surg 2018;26:27-33.
2. Kasikcioglu A, Gulsahi A. Relationship between maxillary sinus pathologies and maxillary posterior tooth periapical pathologies. Oral Radiol 2016;32:180-6.
3. Pagin O, Centurion BS, Rubira-Bullen IR, Alvares Capelozza AL. Maxillary sinus and posterior teeth: Accessing close relationship by cone-beam computed tomographic scanning in a Brazilian population. J Endod 2013;39:748-51.
4. Jacob HB, Geshay D, Carrillo R, Buschang PH. Reliability and applicability of 3D measurements of posterior teeth. J World Fed Orthodont 2014;3:114-8.
5. Sherrard JF, Rossouw PE, Benson BW, Carrillo R, Buschang PH. Accuracy and reliability of tooth and root lengths measured on cone-beam computed tomographs. Am J Orthod Dentofacial Orthop 2010;137:S100-8.
6. Kiljunen T, Kaasalainen T, Suomalainen A, Kortesniemi M. Dental cone beam CT: A review. Phys Med 2015;31:844-60.
7. 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.
8. Fry RR, Patidar DC, Goyal S, Malhotra A. Proximity of maxillary posterior teeth roots to maxillary sinus and adjacent structures using denta scan®. Indian J Dent 2016;7:126-30.
9. Yoshimine S, Nishihara K, Nozoe E, Yoshimine M, Nakamura N. Topographic analysis of maxillary premolars and molars and maxillary sinus using cone beam computed tomography. Implant Dent 2012;21:528-35.
10. Sahlstrand-Johnson P, Jannert M, Strömbeck A, Abul-Kasim K. Computed tomography measurements of different dimensions of maxillary and frontal sinuses. BMC Med Imaging 2011;11:8.
11. Arias-Irimia O, Barona-Dorado C, Santos-Marino JA, Martínez-Rodriguez N, Martínez-González JM. Meta-analysis of the etiology of odontogenic maxillary sinusitis. Med Oral Patol Oral Cir Bucal 2010;15:e70-3.
12. Nunes CA, Guedes OA, Alencar AH, Peters OA, Estrela CR, Estrela C. Evaluation of periapical lesions and their association with maxillary sinus abnormalities on cone-beam computed tomographic images. J Endod 2016;42:42-6.
13. Kim JW, Cho KM, Park SH, Park SR, Lee SS, Lee SK. Chronic maxillary sinusitis caused by root canal overfilling of Calcipex II. Restor Dent Endod 2014;39:63-7.
14. Meng Tian ZZ. Retrospective study for etiologies and treatments of odontogenic maxillary sinusitis. J Oral Sci Res 2015;31:2.
15. 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. J Contemp Dent Pract 2014;15:618-22.
16. Charara K, Friedman S, Sherman A, Kishen A, Malkhassian G, Khakpour M, *et al*. Assessment of apical extrusion during root canal irrigation with the novel GentleWave system in a simulated apical environment. J Endod 2016;42:135-9.
17. Tanasiewicz M, Bubilek-Bogacz A, Twardawa H, Skucha-Nowak M, Szklarski T. Foreign body of endodontic origin in the maxillary sinus. J Dent Sci 2017;12:296-300.
18. Woelber JP, Fleiner J, Rau J, Ratka-Krüger P, Hannig C. Accuracy and Usefulness of CBCT in Periodontology: A Systematic Review of the Literature. Int J Periodontics Restorative Dent 2018;38:289-97.
19. Bhattacharya PT, Patil K, Guledgud MV. Maxillary sinus septa. Int J Stomatol Occlusion Med 2015;8:92-6.
20. Al-Shayyab MH. A simple method to locate mandibular foramen with cone-beam computed tomography and its relevance to oral and maxillofacial surgery: A radio-anatomical study. Surg Radiol Anat 2018;40:625-34.
21. Kang SJ, Shin SI, Herr Y, Kwon YH, Kim GT, Chung JH. Anatomical structures in the maxillary sinus related to lateral sinus elevation: A cone beam computed tomographic analysis. Clin Oral Implants Res 2013;24 Suppl A100:75-81.
22. 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.
23. Tian XM, Qian L, Xin XZ, Wei B, Gong Y. An analysis of the proximity of maxillary posterior teeth to the maxillary sinus using cone-beam computed tomography. J Endod 2016;42:371-7.
24. 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. J Endod 2015;41:1839-46.
25. 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.
26. Georgescu CE, Rusu MC, Sandulescu M, Enache AM, Didilescu AC. Quantitative and qualitative bone analysis in the maxillary lateral region. Surg Radiol Anat 2012;34:551-8.
27. Ananda GK, Nambiar P, Mutalik S, Shanmuhasuntharam P. Anatomical considerations for implant placements in first maxillary molar extracted sites in East Asian patients. Surg Radiol Anat 2015;37:1099-108.
28. Murray P. 4Biocompatibility of biomaterials for dental tissue repair. Biocompat Dent Biomater, Richard Shelton. Woodhead Publishing, U.K. 2017, p. p. 4162.
29. Ghasemi N, Rahimi S, Shahi S, Samiei M, Frough Reyhani M, Ranjkesh B. A review on root anatomy and canal configuration of the maxillary second molars. Iran Endod J 2017;12:1-9.
30. Kwak HH, Park HD, Yoon HR, Kang MK, Koh KS, Kim HJ. Topographic anatomy of the inferior wall of the maxillary sinus in Koreans. Int J Oral Maxillofac Surg 2004;33:382-8.
31. Roberts JA, Drage NA, Davies J, Thomas DW. Effective dose from cone beam CT examinations in dentistry. Br J Radiol 2009;82:35-40.
32. Bhosale S, Rameshkumar M. Endodontic imagingrecent advances: A review. Int Dent J Student Res, 2016;4:1-15.
33. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process; volume assessment by 3-dimensional reconstruction by high-resolutional CT scanning. Otolaryngol Head Neck Surg 2005;132:429-34.