ORIGINAL RESEARCH ARTICLE

Jurnal Radiologi Dentomaksilofasial Indonesia December 2024, Vol. 8, No. 3: 97-102
P-ISSN.2685-0249 | E-ISSN.2686-1321

http://jurnal.pdgi.or.id/index.php/jrdi/index

Correlation of age to classification of vertical relationship of maxillary sinus and maxillary first molar root by cone-beam computed tomography: a cross-sectional study

Mutiara Sukma Suntana[1], Rudi Satria Darwis[2*], Rena Izzatin Nissa[3], Ratna Trisusanti[1]

ABSTRACT

Objectives: The maxillary first molar has a close relationship with the base of the maxillary sinus floor. Cone-beam Computed Tomography (CBCT) provides coronal, sagittal, occlusal, and 3D sectional images of maxillofacial structures without causing distortion. Thus, CBCT allows for a comprehensive analysis of the position of the maxillary first molar about the maxillary sinus. This study aims to determine the correlation between age and the classification of vertical relationship between the maxillary sinus and the roots of the maxillary first molar using CBCT.

Materials and Methods: The research design was the analytical observational research used a cross-sectional design. The study population includes all CBCT radiographs from patients aged 20-50 years who used CBCT at RSGMP Universitas Jenderal Achmad Yani. The total sampling technique was used to include all CBCT radiograph data comforms to the inclusion and exclusion criteria.

Results: The study resulted in 60 CBCT radiographs, with 54 data for the right maxillary first molar and 49 data for the left maxillary first molar. Data analysis using Spearman correlation test showed r = -0.191 with a p-value of 0.166 for the right maxillary first molar and r = -0.167 with a p-value of 0.252 for the left maxillary first molar.

Conclusion: There was no correlation between age and the classification of vertical relationship between the maxillary sinus and the maxillary first molar tooth root ($p > 0.05$). This is because the volume of the maxillary sinus decreases with age, leading to an increased distance between the maxillary sinus and the tooth roots.

Keywords: *Cone-beam computed tomography, maxillary first molar, maxillary sinus, vertical relationship*
Cite this article: Suntana MS, Darwis RS, Nissa RI, Trisusanti R. *Correlation of age to classification of vertical relationship of maxillary sinus and maxillary first molar root by cone-beam computed tomography: a cross-sectional study*. Jurnal Radiologi Dentomaksilofasial Indonesia 2024;8(3)97-102. https://doi.org/10.32793/jrdi.v8i3.1296

INTRODUCTION

The maxillary sinus also known as the antrum highmore is an air space located within the human maxillary bone and is associated with the nasal meatus media on the same side.[1,2] Anatomically, the maxillary sinus is one of the largest paranasal sinuses having a pyramid-like shape, and can vary in size and shape between individuals as well as between the right and left sides.[3,4] The growth process of the maxillary sinus begins in the third month of intrauterine life and reaches complete growth around the age of 20, coinciding with the eruption of all permanent teeth.[5,6] However, when this sinus grows larger than normal, it can result in the roots of molar and premolar teeth becoming closer to the maxillary sinus.[5]

Periapical or periodontal infection of the teeth can lead to odontogenic sinusitis which is one of the common problems associated with the maxillary sinus.[7] Dental treatment involving procedures such as tooth extraction can result in complications related to the relationship between the tooth root tip and the maxillary sinus floor such as root tip fracture, oroantral communication, and root displacement in the maxillary sinus.[8] Some studies have also stated that after tooth extraction, there is an increase in maxillary sinus dimensions and pneumatization, while alveolar bone height and width decrease.[9] Previous studies have shown that odontogenic sinusitis originating from dental infections is one of the common problems associated with the maxillary sinus.[10] Various studies have also identified that the maxillary first molar is the tooth that most often causes abnormalities in the maxillary sinus.[11]

Evaluation of the position of posterior tooth roots with the maxillary sinus is important in diagnosis, dental treatment planning, and prognosis to avoid complications.[8,12] Supporting examinations such as intraoral and extraoral radiographs, including Cone-beam Computed Tomography (CBCT) are used to see the position of molar tooth roots against the maxillary sinus in more detail.[4] The study conducted by Chan Po-Sheng et al. examined patients aged 20 years because the

[1]Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Universitas Jenderal Achmad Yani, Cimahi, Indonesia 40525

[2]Department of Orthodontics, Faculty of Dentistry, Universitas Jenderal Achmad Yani, Cimahi, Indonesia 40525

[3]Faculty of Dentistry, Universitas Jenderal Achmad Yani, Cimahi, Indonesia 40525

*Correspondence to:
Rudi Satria Darwis
rudi.satria@lecture.unjani.ac.id

Received on: October 2024
Revised on: November 2024
Accepted on: December 2024

maxillary sinus had developed and grown completely.[13] Previous research conducted by Carlos on the vertical position of the maxillary sinus with maxillary first molar and second molar roots using the Kwak classification with CBCT radiographs showed that type II was most common.[14] In contrast, Tuba Talo Yildirim et al. showed that type I was most common in the first molar.[15] Differences in results between studies can be caused by differences in methodology, but are also influenced by ethnic characteristics due to diverse populations.[14] Based on the background description above, the authors would like to conduct research related to the correlation of age to the classification of the vertical relationship of the maxillary sinus and the roots of the maxillary first molar teeth through CBCT at RSGMP Unjani. This research is expected to provide a deeper understanding of the age factor in the relationship between these anatomical structures, as well as assist in planning more appropriate dental treatment. This study aims to determine the correlation of age with the classification of the vertical relationship of the maxillary sinus and the roots of the maxillary first molar teeth through CBCT at RSGMP Unjani.

MATERIALS AND METHODS

This research was conducted at the Radiology Installation of Dentistry, Unjani Dental and Oral Education Hospital. The research was conducted from October to December 2023. Ethical approval was obtained through an approval letter from the Ethics Commission of the Faculty of Medicine, Padjajaran University with letter number 1282/ UN6.KEP/EC/2023.

This study used analytic research with cross sectional method. The research sample consisted of CBCT radiographs taken from 2021 to 2023 in patients aged 20-50 years at RSGMP Unjani Cimahi City.The inclusion criteria in this study include patients who have undergone CBCT radiographic examinations at RSGMP Universitas Jenderal Achmad Yani with an age range between 20 to 50 years, and have complete maxillary first molar teeth. The first molar teeth must be fully erupted with well-formed roots. In addition, patients who became research subjects did not use orthodontic devices. Meanwhile, the exclusion criteria were maxillary first molar teeth with unformed apices, root resorption or fracture, shape anomalies, and periapical or periradicular lesions.

This study determined the sample size using the correlative analytic formula, which resulted in a minimum of 31 samples. In its implementation, the total sampling technique was used, which is a sampling technique where the number of samples is equal to the total population of all CBCT radiograph data including inclusion and exclusion criteria available at RSGMP Unjani used for this research sample. The independent variable in this study was age, which was measured on an ordinal scale, while the dependent variable was the classification of the vertical relationship between the maxillary sinus and the maxillary first molar tooth root, which was also measured on an ordinal scale. The study procedure involved analyzing CBCT radiographs in coronal sections. CBCT radiographs were obtained using a CBCT scanner (Soredex Cranex 3Dx) with parameters of 90 kVp, 4 mA, a voxel size of 0.136 mm^3, and a field of view of 4x6 cm^2 or 6x8 cm^2.

The vertical relationship between the maxillary sinus and the maxillary first molar root was assessed based on the classification made by Kwak et al. The data obtained were recorded in tables using Microsoft Excel, and then statistically analyzed using SPSS software. Data analysis included univariate and bivariate analysis. Univariate data analysis aims to determine the classification of the vertical relationship between the maxillary sinus and the maxillary first molar tooth root. This univariate data was then categorized for the purposes of bivariate analysis using the Spearman correlation test, in order to determine the relationship between age and the classification of vertical relationships of the maxillary sinus and maxillary first molar tooth roots on CBCT radiographs at RSGMP Unjani.

RESULTS

Based on Table 1, it shows that the largest sample of research at RSGMP Unjani in 2021-2023 was in the 31-40 year age category, namely 24 people (40%), 21 people (35%) were in the 20-30 year age category and 15 people (25%) were in the 41-50 year age category. Most of the patients in Unjani RSGMP were female, as many as 61.7%, while male patients were 38.3%. Patient characteristics based on age were obtained in 60 medical records and grouped into 20-30 years, 31-

Table 1. Characteristics of patients based on age and gender

		n	%
Age (year)	20-30 year	21	35%
	31-40 year	24	40%
	41-50 year	15	25%
Gender	Female	23	38,3%
	Male	37	61,7%

Table 2. Overview of age ranges with ingrown maxillary first molar roots in the maxillary sinus

	Age	No entry into the maxillary sinus	Entry into the maxillary sinus
Right	20-30 year	4 (20%)	16 (80%)
	31-40 year	2 (8,3%)	22 (91,7%)
	41-50 year	6 (60%)	4(40%)
Left	20-30 year	4 (22,2%)	14 (77,8%)
	31-40 year	1 (40%)	20 (95,2%)
	41-50 year	4 (18,4%)	6 (60%)

Table 3. Classification of vertical relationship of maxillary sinus and root of maxillary first molar teeth

	Right maxillary first molar		Left maxillary first molar		Total
	Total (n)	Percentage (%)	Total (n)	Percentage (%)	
Type I	4	7,4	3	6,1	7
Type II	8	14,8	6	12,2	14
Type III	7	13	4	8,2	11
Type IV	13	24,1	13	26,5	26
Type V	22	40,7	23	46,9	45

40 years, and 41-50 years.

Classification of the vertical relationship of the maxillary sinus and maxillary first molar according to Kwak et al. namely type I buccal and palatal roots of molar teeth do not come into contact with the sinus floor, type II buccal and palatal roots of molar teeth come into contact with the sinus floor, type III buccal roots of molar teeth penetrate into the sinus cavity above the maxillary sinus floor, type IV palatal roots of molar teeth penetrate into the sinus cavity above the maxillary sinus floor, type V buccal and palatal roots penetrate into the sinus cavity above the maxillary sinus floor. Type I and type II classifications of molar roots do not enter the sinus, while type III, type IV, and type V molar roots enter the sinus. An overview of the age range with non-entry and entry of the first molar root into the maxillary sinus can be seen in Table 2.

Based on Table 2, it can be seen that in the age range of 31-40 years, the highest number of maxillary right first molar roots entered the maxillary sinus. Similarly, in the maxillary left molar in the age range of 31-40 years.

Table 3 shows that the highest number is found in type V classification for vertical relationship of maxillary sinus and maxillary right first molar root, while type I has the lowest number. The percentage in each classification is type I 7.4%; type II 14.8%; type III 13%; type IV 24.1%; type V 40.7%. Similarly, in the maxillary sinus and left first molar root, type V had the highest number, while type I had the lowest number. The percentage in each classification is type I 6.1%; type II 12.2%; type III 8.2%; type IV 26.5%; type V 46.9%.

Figure 1 shows that the classification of the vertical relationship between the maxillary sinus and the roots of the right first molar tooth in the age category 20-30 years, the highest number is type V, namely the buccal and palatal roots penetrate into the sinus cavity above the base of the maxillary sinus, age 31-40 years, the highest number is type V classification as in early adulthood, and age 41-50 years, the highest number is type II, namely the buccal and palatal roots of the molar teeth are in contact with the

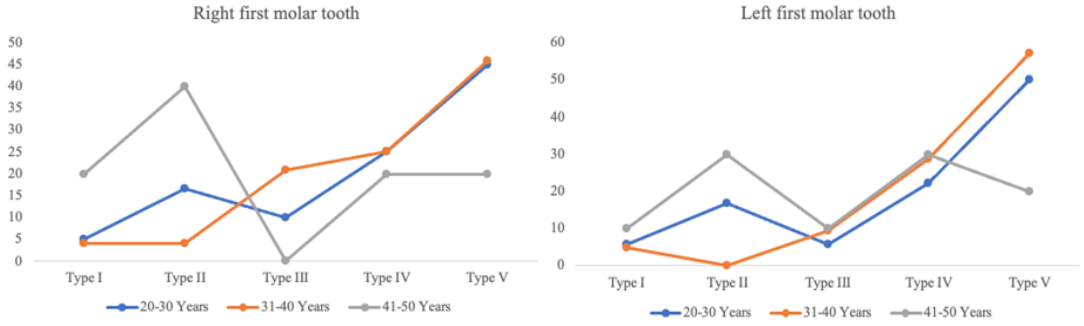

Figure 1. Graphical representation of age by classification of vertical relationship of maxillary sinus and maxillary first molar root

Jurnal Radiologi Dentomaksilofasial Indonesia 2024; 8(3); 97-102 | DOI: 10.32793/jrdi.v8i3.1296

Table 4. Correlation test results between age and vertical relationship classification of maxillary sinus and maxillary first molar root by CBCT

	r	*P value*
Right first molar	*-0,191*	*0,166*
Left first molar	*-0,167*	*0,252*

*Notes: Spearman Correlation Test with: $p < 0.05$ (significant)

sinus base.

Classification of the vertical relationship between the maxillary sinus and the roots of the left first molar tooth in the age category 20-30 years, the highest number of type V is obtained, namely the buccal and palatal roots penetrate into the sinus cavity above the base of the maxillary sinus, age 31-40 years, the highest number in type V classification as in early adulthood, and age 41-50 years, the highest number in type II, namely the buccal and palatal roots of the molar teeth are in contact with the sinus base and type IV, namely the palatal roots of the molar teeth penetrate into the sinus cavity above the base of the maxillary sinus.

Based on Table 4, it can be seen that in the maxillary right first molar with a right first molar correlation value of -0.191 which means that the strength of the correlation between age and the classification of the vertical relationship between the maxillary sinus and the roots of the maxillary first molar is weak. The correlation value obtained is negative, which means that the relationship between the two variables is not unidirectional or opposite and can be interpreted that the higher the age, the lower the classification of the vertical relationship between the maxillary sinus and the maxillary first molar tooth root (p-value = 0.166). The statistical test results show that there is no correlation between age and the classification of vertical relationship between maxillary sinus and maxillary first molar root.

The maxillary left first molar with a left first molar correlation value of -0.167 which means that the strength of the correlation between age and the classification of the vertical relationship between the maxillary sinus and the maxillary first molar root is weak. The correlation value obtained is negative, which means that the relationship between the two variables is not unidirectional or opposite and can be interpreted that the higher the age, the lower the classification of the vertical relationship between the maxillary sinus and the maxillary first molar tooth root (p-value = 0.252). The statistical test results show that there is no correlation between age and the classification of the vertical relationship of the maxillary sinus and maxillary first molar tooth roots.

DISCUSSION

This study shows that the most common classification of the vertical relationship of the roots of the maxillary right first molar tooth with the maxillary sinus is in the type V classification, namely the buccal and palatal roots penetrate into the sinus cavity above the base of the maxillary sinus as much as 40.7%, and the lowest number is in the type I classification, namely the buccal and palatal roots of the molar teeth are not in contact with the sinus base as much as 7.4% (Figure 1). The results of the number of classifications of the vertical relationship of the roots of the left first molar tooth with the maxillary sinus show the same results as the right first molar tooth with the highest number being type V as much as 46.9% and the lowest number being type I as much as 6.1% (Figure 1).

The results of this study are supported by research conducted by Anna et al. regarding the relationship between the roots of the maxillary teeth and the base of the maxillary sinus conducted in Poland stated that the classification of vertical relationship type V which means that both tooth roots have penetrated the base of the maxillary sinus is the highest number of 43.18%, while type I has the lowest number of about 11.36%. [16] The results of the classifications of the vertical relationship of the roots of the left first molar tooth with the maxillary sinus showed the same results as the right first molar tooth with the highest number of type V at 71.79%, while type I had the lowest number of 5.13%.[16] This occurs because the floor of the maxillary sinus is formed by the alveolaris processus and the maxillary palate, with the lowest part of the maxillary sinus floor generally being between the roots of the first molar and second molar.[17]

The results of this study show differences with research conducted by Carlos et al, which found that the highest number of classification of the relationship between the roots of the maxillary first molar teeth and the maxillary sinus is type II reaching 44.67%, while type V has the lowest number of about 4.67%.[14] The difference in results between this study and the research conducted by Carlos et al, can not only be attributed to differences in research methods, but also to the diversity of ethnic characteristics in the population analyzed.[18] The results of this study show that there is no correlation between age and vertical relationship classification of maxillary sinus and maxillary first molar tooth roots.

The results of this study showed that there was no correlation between age and the classification of vertical relationship between maxillary sinus and maxillary first molar root. This could be due to the unequal population size in all categories. The results of the classification of the vertical relationship of the maxillary sinus and the roots of the right first molar teeth based on age were obtained in the age category 20-30 years the largest number was type V, age 31-40 years the largest number was type V, and age category 41-50 years the largest number was type II. This shows that in this study the

increasing age, the lower the vertical relationship classification.

The Tian et al. study used three vertical relationship classifications, namely Type IS root tip extending upward or inside the maxillary sinus floor, Type CO root in contact with the maxillary sinus floor, and Type OS root extending downward or outside the sinus floor. The study showed that with increasing age, the frequency of premolar and molar root IS type decreased in the Chinese population. Type IS was common in the age group of 20 to 40 years and rare in the age group of more than 60 years.[19] This suggests that the average distance of maxillary molar teeth to the sinus floor increases with age.[19]

Maxillary sinus volume development generally ends at the age of 21 to 30 years when the maxillary third molar has erupted.[20] Maxillary sinus volume will decrease after the maxillamal growth period and the sinus floor can move upward, unless there is a disturbance such as tooth extraction that causes sinus pneumatization.[20] Reduced maxillary sinus volume can be caused by mineral loss in the bone matrix of all body structures surrounding the maxillary sinus, causing maxillary sinus contraction.[21] However, this change can occur faster or slower depending on the individual.

Research conducted by Juni Pei et al. showed that the distance between the roots of molar teeth and the base of the maxillary sinus increases with age. This finding suggests that the risk of molar tooth extraction, endodontic therapy, or implant placement is relatively higher in the adolescent age group.[22] In addition, genetic, environmental, habitual, and racial factors can affect the size of the maxillary sinus.[23]

Genetic factors can cause anatomical variations in each human due to differences in human inherited genetics. In addition to genetic factors, anatomical variations can also be influenced by environmental factors.[23] The body's anatomy tends to adapt to the environmental conditions in which the individual lives, so each person living in a different environment may show higher anatomical variations.[23] Individual habits can be a contributing factor to maxillary sinus variation in humans, for example, smoke and harmful substances from smoking can cause irritation to the lining. In addition, alcohol consumption can also cause swelling of the nasal membranes and sinuses.[23] So it is important to evaluate the relationship between the maxillary sinus and the maxillary first molar roots to avoid complications during or after dental treatment.[8]

CONCLUSION

The root of themaxillary first molar tooth entering the maxillary sinus reaches the highest number in the age range of 31-40 years. The vertical relationship between the maxillary sinus and the root of the right first molar tooth, according to Kwak's classification, can be divided into five types starting from the highest number of type V, type IV, type II, type III, type I. Meanwhile, the roots of the left maxillary first molar tooth are type V, type IV, type II, type III, type I. However, there is no significant correlation between age and classification of vertical relationship of maxillary sinus with maxillary first molar root.

ACKNOWLEDGMENTS

None.

FOOTNOTES

All authors have no potential conflict of interest to declare for this article. This study was conducted in accordance with the declaration of Helsinki and was approved by the Research Ethics Committee of Padjadjaran University Bandung (1282/UN6.KEP/EC/2023) on October 19, 2023. All procedures conducted were in accordance with the ethical standards.

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