

Maxillary Sinus Pneumatization and Its Relationship with Vitamin D Deficiency; A Cross Sectional Study

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Abstract

Objectives: To identify any correlation and its severity with the levels of serum vitamin D with the level of maxillary sinus pneumatization.

Study Design: Descriptive cross-sectional survey.

Setting: Oral and Maxillofacial Department, Fatima Memorial Hospital, Lahore.

Materials and Methods: A sample size of 100 subjects met the inclusion criteria. Serum Vitamin D levels of the patients was done using liquid chromatography tandem mass spectrometry, also known as LC/MS/MS. While level of sinus pneumatization was recorded according to Sharan and Majdar classification of maxillary sinus pneumatization. Data was collected and entered into the Statistical Package for Social Science (SPSS) version 25.0 for analysis. Parametric analysis was performed that included the Pearson's Chi-Square test to determine an association between excessive maxillary sinus pneumatization and hypovitaminosis. A p-value of <0.05 was defined as the level of significance.

Results: A statistically significant relationship was found between levels of hypovitaminosis and levels of pneumatization with a chi square value to be 0.002 ($p < 0.05$) While there was no statistically significant relationship of age or gender with levels of maxillary sinus pneumatization and hypovitaminosis D ($p > 0.05$).

Conclusion: There is a significant relationship between levels of hypovitaminosis and levels of pneumatisation.

Keywords: Hypovitaminosis D, Maxillary Sinus, Sinus Pneumatization

Introduction

Pneumatization of the maxillary sinus is a physiological process that occurs in all paranasal sinuses during the growth period in which they increase in size. The maxillary sinus is the largest of all the paranasal sinuses. It is the first to develop of all sinuses at 10 weeks in utero and becomes identifiable at 16 weeks in utero [1,2]. After birth, the sinus continues to pneumatize into the developing alveolar ridge as the permanent teeth erupt. At 12 to 13 years, the sinus floor is level with the nasal floor, and at the age of 20, with the completion of the eruption of the third molars, the pneumatization of the sinus ends,

and under normal circumstances, the sinus reaches 5 mm inferior to the nasal floor [1,2]. Physiological pneumatization occurs with the aging process. Excessive pneumatization of the paranasal sinuses has been observed even in younger patients [1]. This excessive maxillary sinus pneumatization (EMSP) can have significant treatment planning implications in oral and maxillofacial Surgery. It may complicate maxillary extractions with higher possibility of oro-antral communication/ fistula development. With the advent of dental implants, significance of pneumatization has increased even further. In patients with increased pneumatization, an additional surgical procedure of sinus lift is carried out, which involves sub-periosteal sinus floor mucosal elevation with bone grafting to provide bone all around the dental implants [3]. Also, excessive maxillary sinus

pneumatization can complicate pre-prosthetic surgical procedures like Maxillary tuberoplasty [1]. The reasons for excessive sinus pneumatization are not completely known. Among the factors that influence this process are heredity, the pneumatization drive of the mucous membrane of the nose, craniofacial configuration, and density of the surrounding bone, growth hormones, sinus air pressure, and sinus surgery [1,2]. Whether Vitamin D deficiency is a factor in causing increased pneumatization of the maxillary sinus is not clear.

Hypovitaminosis D is a deficiency of vitamin D. It can result from inadequate nutritional intake of vitamin D coupled with inadequate sunlight exposure, disorders that limit vitamin D absorption, and conditions that impair the conversion of vitamin D into active metabolites including certain liver, kidney, and hereditary disorders [4]. Deficiency results in impaired bone mineralization and leads to bone softening diseases including rickets in children and osteomalacia and osteoporosis in adults. Vitamin D3 deficiency has become current health issue worldwide. In Pakistan different studies from different sites have reported a deficiency of 25(OH) vitamin D3 in 97% healthy population [4].

Vitamin D deficiency results in an increase in parathyroid hormone levels, which in turn increases osteoclastic activity, resulting in the removal of the matrix and mineral from the skeleton. Histological examination shows that the pneumatization process of the maxillary sinus occurs by osteoclastic resorption of the cortical walls of the sinus and the layering of osteoid inferior to it [1]. This may suggest that hypovitaminosis D may also have a role in increased pneumatization of maxillary sinuses. The basis of increase in size of the maxillary sinus is multifactorial and includes congenital and acquired variants [5].

Excessive maxillary sinus pneumatization and serum hypovitaminosis D are well known entities but the relationship between the two has received little recognition in the literature. Both are common conditions affecting the adult population especially in countries like Pakistan due to various socio-economic and cultural factors. The aim of this study is to identify a possible relationship between them. Any positive correlation found can help in early diagnosis of Vitamin D deficiency in routine orthopantomogram and subsequently can help reduce Vitamin D deficiency related morbidities with early Vitamin D supplementation and life style modifications.

Material and Methods

Study Design

We conducted a cross sectional descriptive study of excessively pneumatized maxillary sinuses that were obtained for adult outpatients encountered in our hospital during from 17th June 2018 to 17th January 2019. The orthopantomograms (OPGs) were performed at the Radiological Department, Fatima Memorial Hospital, Shadman, Lahore. A total of 100 cases included 30 males (age 20 to 40 years old, mean age=26.6 years) and 70 females (20 to 40 years old, mean age=26.8 years).

Study Selection Criteria

Before starting the study, a series of inclusion and exclusion criteria were established.

The inclusion criteria included:

1. Adult patients ranging from ages 20 years to 40 visiting the dental OPD
2. Patients who gave the consent to be included in the study

3. Patients having maxillary molars and pre-molars on clinical assessment
4. Patients with normal Dental Crown to Root ratio on OPG evaluation (1:2)
5. As well as only the good quality OPG records (not pale, not dark, no artifact and no overlap) in both fully dentate and partially edentulous adult patients were included
6. Patients having no history of head and sinus injury
7. No history of sinonasal surgery
8. and no history of paranasal sinus neoplasms

On the contrary, all patients below 20 years, presence of intra-sinus lesion, complex skeletal alterations, relevant skeletal asymmetries; chronic systemic disease, bone tumors as well as patients with a history of sinus surgery, sinus trauma, extensive caries or restorations, retained roots, impacted and unerupted or root treated maxillary teeth were excluded. As well as individuals with renal, liver or gastrointestinal disease and those receiving any form of drug treatment that could possibly affect bone metabolism (for example, calcitonin, corticosteroids, anticonvulsants, or thyroid hormones) were also excluded from the study.

Sampling and Sample Size Calculation

Patients were independently recruited using random sampling technique where every patient had an equal chance of being included in the study. A sample size of 100 cases was decided based on a prior pilot study on 20 patients and was calculated with 95% confidence level, 9% margin of error.

OPG Examination and Analysis

All the dental OPGs were done using a Carestream Kodak OPG Dental Machine using a tube voltage of 60-90 kv and 2-15 mA tube current at a frequency of 140 kHz for all patients in the neutral head position with an exposure time of 18 seconds. Appropriate entries were made in the structured study perform (Annex A) by the researcher. Pneumatization status of maxillary sinuses was labeled according to Sharan and Majdar classification (Table 1) [2].

Determination Standard of Serum Vitamin D Levels

Serum Vitamin D levels of the patients was done using liquid chromatography tandem mass spectrometry, also known as LC/MS/MS. Serum was separated and stored at - 80°C until analysis. Serum vitamin D levels were classified according to WHO as normal (40-80 ng/dl), insufficient (20-40ng/dl), deficient (10-20ng/dl), severely deficient (0-10ng/ml).

Assessing Level of Maxillary Sinus Pneumatization

Level of sinus pneumatization was recorded according to Sharan and Majdar classification of maxillary sinus pneumatization in a dentate. The classification included; 0) The root is not in contact with the cortical borders of the sinus; 1) an inferiorly curving sinus floor, with the root in contact with the cortical borders of the Sinus; 2) an inferiorly curving sinus floor, with the root projecting laterally on the Sinus cavity but with the root apex outside the sinus boundaries; 3) an inferiorly curving sinus floor, with the root apex projecting in the Sinus cavity and 4) a superiorly curving sinus floor enveloping part of all of the tooth roots.

Ethical Considerations

This study was approved by Institutional review board of Fatima Memorial Medical and Dental College. All collected data were

kept confidential and in compliance with the Helsinki declaration. Participants were informed on the risks and benefits and their right not to provide information, or to withdraw from the study at any time without any sort of penalty. An informed consent was obtained from all participants.

Statistical Analyses

Data was collected and entered into Microsoft Office Excel and imported into the Statistical Package for Social Science (SPSS) version 25.0 for analysis. Descriptive statistics were used to report sample characteristics. Categorical variables e.g. gender was reported as frequency and percentages and continuous variables e.g. age were reported as mean/± Standard deviation (SD). Parametric analysis was performed that included the Pearson's Chi-Square test to determine an association between excessive maxillary sinus pneumatization and hypovitaminosis. A p-value of <0.05 was defined as the level of significance.

Results

The ages of patients ranged from 20 to 40 years while the mean age patients recruited was 26.03±6.72 years and 26.08 ±6.09 years. There were 30 males (30%) and 70 females (70%) in the study. 56% of the participants were found to be severely deficient in vitamin D levels. While 32% of the total subjects were seen to have deficient levels of vitamin D followed by only 12% having insufficient levels

of vitamin D.

Of the female participants, 61% were severely deficient, 28% were deficient and 10% had insufficient vitamin D levels. Alternatively, in males, 43% were severely deficient, 40% were deficient and 16% had insufficient levels of vitamin D.

Whereas, 40% of the participants had level 4 excessive sinus pneumatization. Of which, 65% were females and 35% were males. Second highest level of sinus pneumatization were seen in level 2 which were 31% which included; 74% females and 25% males. Followed by level 1 pneumatization which was 18% of the total subjects in which 72% females were included and 27% males. The least levels of pneumatization were seen in level 3 with only 11% of the total subjects of which 72% were females and 27% were males.

There was no statistically significant relationship of age or gender with levels of maxillary sinus pneumatization and hypovitaminosis D (p>0.05).

However, a statistically significant relationship was found between levels of hypovitaminosis and levels of pneumatization with a chi square value to be 0.002 (p<0.05) hence proving the alternative hypothesis; serum vitamin levels maybe a factor associated with excessive pneumatization of maxillary sinus in adults.

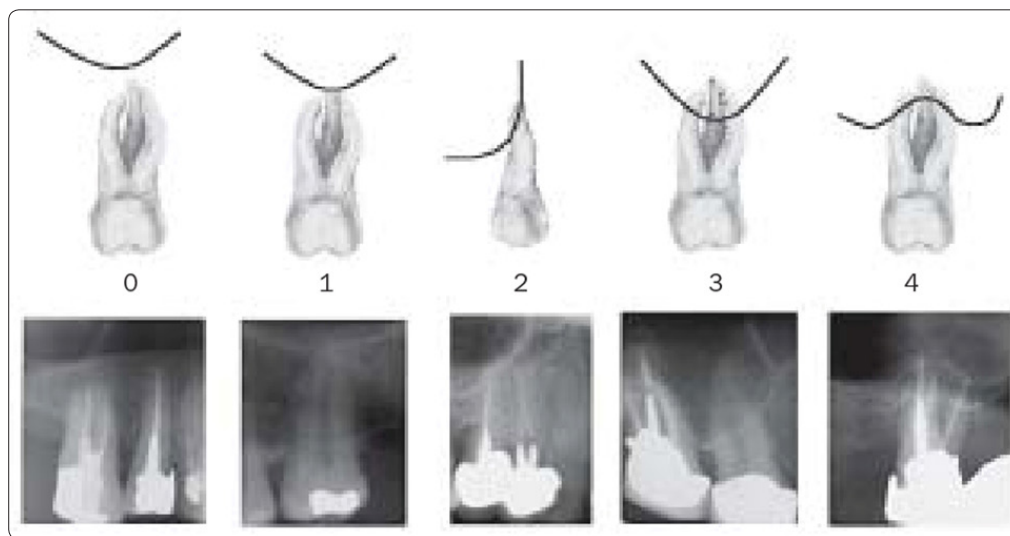


Figure 1: Schematic illustration and panoramic images of 5 classifications of maxillary posterior teeth roots in relation to the inferior wall of the sinus. 0) The root is not in contact with the cortical borders of the sinus; 1) an inferiorly curving sinus floor, with the root in contact with the cortical borders of the sinus; 2) an inferiorly curving sinus floor, with the root projecting laterally on the sinus cavity but with the root apex outside the sinus boundaries; 3) an inferiorly curving sinus floor, with the root apex projecting on the sinus cavity; 4) a superiorly curving sinus floor enveloping part or all of the tooth root

Table : Relationship of hypovitaminosis D and excessive maxillary sinus pneumatization

Levels of hypovitaminosis D	Frequency of maxillary sinus pneumatization					P value
	Class 1	Class 2	Class 3	Class 4	Total	
Insufficient (20-4-ng/dl)	2	0	2	8	12	0.002
Deficient (10-20ng/dl)	12	11	3	6	32	
Severely Deficient (0-10ng/dl)	4	20	6	26	56	

Test Utilized: Pearson's Chi Square Test

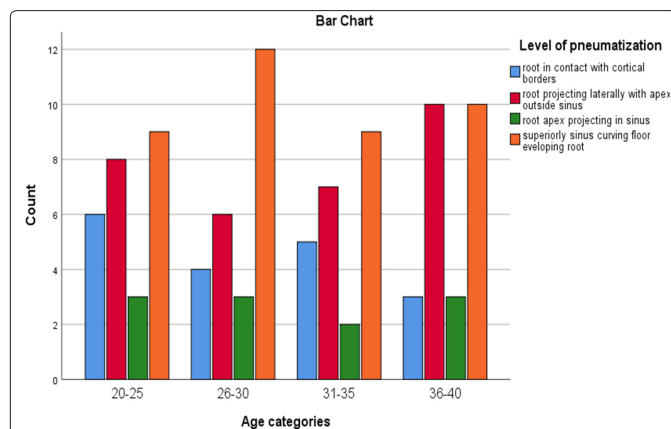


Figure 2: Clustered bar chart of percentages of maxillary sinus pneumatization categories in each age category

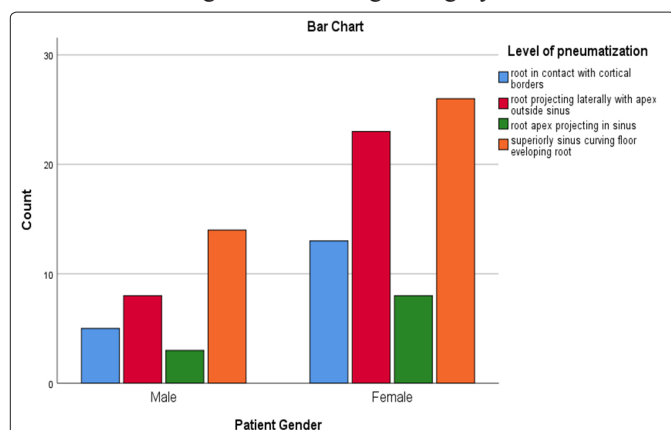


Figure 3: Clustered bar chart of percentages of maxillary sinus pneumatization categories in each gender

Discussion

To the best of the author's knowledge, this study is the first to have evaluated the relationship between pneumatization of maxillary sinus and vitamin D deficiency and to fully explore the severity of hypovitaminosis D as a risk factor. The author's assessment of the vitamin D deficiency and its severity as a risk factor of pneumatization of maxillary sinus was carried out to generate data which can be used to determine better ways of detection of hypovitaminosis D. This can lead to better and early treatment options as well as for dentists to see it as a risk factor for all future treatment plans of the patient. Thus, enabling dentists to avoid further complications which can be caused if procedures like implants are carried out on compromised patients.

The maxillary sinus begins as a small lateral growth of the ethmo-maxillary recess mucosa during the 10th to 12th weeks of gestation. This is associated with resorption of the surrounding tissue and growth of the maxillary pouch. The maxillary antrum becomes discernable at the 16th week of gestation. The pneumatization process continues mainly in an inferior direction after eruption of the maxillary teeth. Adult size is reached by the age of 15 to 18. The maxillary sinus pneumatization may extend into nearby bony elements as recesses - inferomedial into hard palate, laterally into zygomatic bone and posteriorly into ethmoids. Excessive Maxillary sinus pneumatization (EMSP) is defined as larger than normal adult size of the maxillary sinus and is known to be caused physiologically with age and extraction of maxillary posterior teeth while pathologically due to many endocrine and bony conditions like hyperparathyroidism. Surprisingly, ESMP has received little attention in the literature.

The present study's primary objective was to find a correlation if any, of vitamin D deficiency with pneumatization of maxillary sinus. We found a strong co relation between maxillary sinus pneumatization and its severity with vitamin D deficiency, where the p value was 0.002 (<0.005).

While secondary objectives included finding the prevalence of both, vitamin D deficiency and maxillary sinus pneumatization.

One of our key findings demonstrated that there were inequalities in vitamin D deficiency were encountered between the two genders. This study concluded that of the female participants, 61% were severely deficient, 28% were deficient and 10% had insufficient vitamin D levels. Whereas, in the male participants, 43% were severely deficient, 40% were deficient and 16% had insufficient levels of vitamin D. Hence the results have also confirmed the gender differences in vitamin D deficiency seen in other studies [6].

Although a global issue, hypovitaminosis D is especially emphasized in the literature covering the Middle East due to a number of interesting paradoxes. Middle East receives abundant sunlight all year round. However, contemporary studies show a high prevalence of hypovitaminosis D among women of different age-groups. These finding are attributed mainly to inadequate exposure to sunlight either because of the dressing style or avoidance of extremely hot sun [7-9].

Although previously, the studies failed to attribute the detected higher prevalence of vitamin D deficiency in the middle eastern region to inadequate sun exposure or sub-optimal intake of dairy products [10]. One possible reason for the high rates of vitamin

D deficiency in this region was postulated to be attributed to the high level of air pollution in this region, as air pollution reduces skin exposure to ultraviolet rays [11]. Despite that some studies did not find an association between clothing habits and vitamin D deficiency, others postulated that the conservative culture and concealed clothing style of females as well as poor dietary intake were potential causes of low rates of sun exposure and high rates of vitamin D deficiency [4,6,12,13].

Our results also showed that 40% of the participants had level 4 maxillary sinus pneumatization, hence proving that an excessive degree of maxillary sinus pneumatization prevailed in our population and may be attributed to other unexplored factors, e.g. epigenetic environmental etiology. Expansion of the maxillary sinus with severe thinning of the bony floor was obvious and appeared in the OPGs of large percentages of the present sample which will increase the demand of ridge augmentation and extensive bone regeneration before implant placement in the future.

The anatomic relation between sinus floor and dentition is a misunderstanding to some young dentists who may think that the teeth and alveolus is related to the nasal cavity which is a completely wrong concept. In reality, the posterior maxillary teeth are related to the sinus floor and the distance between them may vary from a good bony bridge to a very close approximation to the floor. In which cases, an impression of the root apices presents on the only separating thin lining mucosa [14]. Environmental factors may play a role in the etiology of this condition, which lead to pushing of the Schneiderian membrane (highly reactive membrane) against cavity sides of the sinus following every patient's breath. Hence this enforces the evidence towards environmental factors besides bone weakening disorders such as vitamin D deficiency. Other risk factor of increasing maxillary sinus pneumatization should be investigated in future studies.

The strength of the current study is that it is the first of its kind and the one that describes the degree of maxillary sinus pneumatization in our region but the study requires further supplemental study to further strengthen the association and establish it as a fact.

Study Limitations

Although our study used an objective, valid and reliable measure for maxillary sinus pneumatization and serum vitamin D level, we were not able to control for several risk factors, which may impact vitamin D serum level as well as maxillary sinus pneumatization, among them are the smoking habits and the full nutritional habits pattern. There is a need for more in-depth research to understand the nutritional pattern and full life style practices in the country that may affect vitamin D serum level and other environmental as well as genetic factors associated with maxillary sinus pneumatization.

Conclusion

High percentages of patients were with significant severe maxillary pneumatization. Notably, this significant was highly correlated with young adults and adult age groups, as well as female gender and most importantly severe deficient vitamin D, highlighting the need to replicate these findings and explore the role of other factors (e.g. environment and genetics) in maxillary sinus pneumatization. Further investigational studies should be considered to investigate other associated significant predictive risk factor initiating this hidden epidemic condition.

References

1. Sharan A, Madjar D (2008) Maxillary sinus pneumatization following extractions: a radiographic study. *The International journal of oral & maxillofacial implants* 23: 48-56.
2. Kalavagunta S, Reddy KT (2003) Extensive maxillary sinus pneumatization 41: 113-117.
3. Riben C, Thor A (2012) The Maxillary Sinus Membrane Elevation Procedure: Augmentation of Bone around Dental Implants without Grafts-A Review of a Surgical Technique. *International journal of dentistry* 2012: 105483.
4. Iqbal R, Khan AH (2010) Possible causes of vitamin D deficiency (VDD) in Pakistani population residing in Pakistan. *JPMA The Journal of the Pakistan Medical Association* 60: 1-2.
5. Lawson W, Patel ZM, Lin FY (2008) The development and pathologic processes that influence maxillary sinus pneumatization. *Anatomical record (Hoboken, NJ : 2007)* 291: 1554-1563.
6. Hashemipour S, Larijani B, Adibi H, Javadi E, Sedaghat M, et al. (2004) Vitamin D deficiency and causative factors in the population of Tehran. *BMC Public Health* 4: 38.
7. Shahla CS, Talebi R, Omrani M (2005) Vitamin D Deficiency in Young Females with Musculoskeletal Complaints in Urmia, Northwest of Iran. *IJMS* 30: 88-90.
8. Saadi HF NN, Benedict S, Qazaq HS, Zilahi E, Mohamadiyeh MK, et al. (2006) Predictors and relationships of serum 25 hydroxyvitamin D concentration with bone turnover markers, bone mineral density, and vitamin D receptor genotype in Emirati women. *Bone* 39: 1136-1143.
9. Bener A A-AM, Hoffmann GF (2009) High prevalence of vitamin D deficiency in young children in a highly sunny humid country: a global health problem," *Minerva Pediatrica* 61: 15-22.
10. Elsamak MY, Al-Wossaibi AA, Al-Howeish A, Alsaed J (2011) High prevalence of vitamin D deficiency in the sunny Eastern region of Saudi Arabia: a hospital-based study. *Eastern Mediterranean health journal = La revue de sante de la Mediterranee orientale = al-Majallah al-sihhiyah li-sharq al-mutawassit* 17: 317-322.
11. Prentice A (2008) Vitamin D deficiency: a global perspective. *Nutrition Reviews* 66: S153-S164.
12. Sedrani SH, Elidrissy AW, El Arabi KM (1983) Sunlight and vitamin D status in normal Saudi subjects. *The American journal of clinical nutrition* 38: 129-132.
13. Javed R, Yasmin Malik S, Yaqub S, Ghafoor F, Asim M (2012) Levels of 25-OH Vitamin D in Healthy Asymptomatic Adults: Pilot Study 51: 82A.
14. Shahbazian M, Xue Dong, Yuqian Hu, Johan van Cleynenbreugel, Reinhilde Jacobs (2010) Spiral computed tomography based maxillary sinus imaging in relation to tooth loss, implant placement and potential grafting procedure. *J Oral Maxillofac Res* 1: e7.

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