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RESEARCH ARTICLE
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ANATOMICAL VARIATION OF MAXILLARY SINUS AND ITS RELATION WITH PERIODONTAL DISEASES IN KP POPULATION USING CBCT AND PERIODONTAL CLINICAL ASSESSMENT

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ABSTRACT

Background

The maxillary sinus shares a close anatomical relationship with the posterior teeth, which may influence periodontal disease progression. This study aimed to evaluate the impact of anatomical variations in the maxillary sinus on periodontal health using radiological assessment.

Methodology

A cross-sectional study was conducted at Khyber College of Dentistry Peshawar and Ayub College of Dentistry, Abbottabad, from March 2023 to March 2024. A total of 73 patients were included based on specific inclusion criteria. Periodontal parameters, including pocket depth, clinical attachment loss, bleeding on probing, and tooth mobility, were assessed clinically. Cone-beam computed tomography (CBCT) was used to evaluate sinus variations such as sinus septa, pneumatization, mucosal thickening, and proximity of the sinus floor to posterior tooth roots. Statistical analysis was performed using SPSS version 25, with chi-square and t-tests applied to determine significant associations ($p < 0.05$).

Results

Sinus floor pneumatization was significantly associated with increased periodontal attachment loss ($p = 0.025$), suggesting a role in bone resorption. Mucosal thickening correlated with deeper periodontal pockets and greater inflammation ($p = 0.019$). The presence of sinus septa was also linked to more severe periodontal conditions ($p = 0.048$), likely due to altered sinus drainage and localized pressure effects. Root proximity to the sinus was another significant factor, with cases of close contact showing higher rates of periodontal deterioration ($p = 0.041$). Smoking and snuff missing teeth adjacent to the sinus further contributed to disease severity.

Conclusion
This study highlights the influence of maxillary sinus anatomical variations on periodontal disease progression. Factors such as sinus pneumatization, mucosal thickening, and root proximity may exacerbate periodontal breakdown, reinforcing the need for a multidisciplinary approach in diagnosis and treatment planning. CBCT imaging plays a vital role in identifying these variations, allowing for more effective periodontal management.

Keywords: maxillary sinus, periodontal disease, anatomical variations, CBCT, sinus pneumatization, mucosal thickening, root proximity, periodontal progression

INTRODUCTION

The maxillary sinus, the largest of the paranasal sinuses, plays an essential role in craniofacial function and health. Its close anatomical relationship with the upper posterior teeth makes it highly relevant in dental and periodontal conditions(1). The position of the sinus floor and its variations can significantly influence oral health, particularly in cases of periodontal disease. Anatomical differences in the maxillary sinus, such as pneumatization, septa, and mucosal thickening, may affect the surrounding bone and soft tissues, potentially contributing to periodontal disease progression(2).

Periodontal disease is a chronic inflammatory condition that leads to the destruction of the supporting structures of teeth, including the alveolar bone(3). The extent of bone loss is influenced by multiple factors, including microbial infections, systemic conditions, and anatomical variations. When the maxillary sinus is positioned close to the roots of the posterior teeth, infections or inflammatory changes within the sinus can exacerbate periodontal tissue destruction(4). Additionally, sinus pneumatization following tooth loss may further complicate periodontal treatment and bone regeneration efforts.

Radiographic imaging, particularly cone-beam computed tomography (CBCT), provides valuable insights into the structural variations of the maxillary sinus. CBCT allows for precise evaluation of sinus floor height, root proximity, and mucosal changes, making it a crucial tool in understanding the impact of sinus anatomy on periodontal disease. By identifying anatomical risk factors, clinicians can enhance treatment planning and improve patient outcomes, particularly in cases requiring periodontal therapy, dental implants, or sinus-related surgical procedures(5, 6).

This study aims to explore the relationship between maxillary sinus variations and periodontal disease progression through radiological assessment. By analyzing sinus floor pneumatization, sinus septa, mucosal thickening, and root proximity, this research seeks to determine how these variations contribute to the severity of periodontal disease. Understanding these associations may help clinicians adopt a more comprehensive approach in diagnosing and managing periodontal conditions, considering both dental and sinus health in treatment planning.

METHODOLOGY

This cross-sectional study was conducted at Khyber College of Dentistry Peshawar and Ayub College of Dentistry, Abbottabad, from March 2023 to March 2024. The research aimed to assess how anatomical variations in the maxillary sinus influence periodontal disease progression using radiological analysis. Ethical approval was obtained from the Ethical Review Committee of Khyber College of Dentistry Peshawar and Ayub College of Dentistry, Abbottabad. All participants provided written informed consent, and confidentiality of patient data was maintained throughout the study.

A total of 73 patients were included in the study, selected through a non-probability consecutive sampling method. The inclusion criteria consisted of adults aged 18 years and above, individuals with at least one posterior tooth adjacent to the maxillary sinus, patients diagnosed with periodontal disease of varying severity, and those requiring cone-beam computed tomography (CBCT) scans for dental evaluation.

Exclusion criteria included patients with a history of maxillofacial trauma or surgery, systemic conditions affecting bone metabolism such as osteoporosis or uncontrolled diabetes, previous sinus surgery, or long-term use of antibiotics or corticosteroids.

Data Collection Procedure

Patients visiting the Periodontology and Radiology Departments of Khyber College of Dentistry Peshawar and AyubCollege of Dentistry, Abbottabadwere screened based on the inclusion and exclusion criteria. Those eligible provided written informed consent before data collection. Demographic details, smoking and snuff status, and medical history were recorded. Each participant underwent a comprehensive periodontal examination, where pocket depth, clinical attachment loss, bleeding on probing, gingival recession, and tooth mobility were measured.

Radiological Assessment

Cone-beam computed tomography (CBCT) was performed to assess maxillary sinus anatomy. The scans were taken using a standardized field of view and voxel size to ensure high-resolution imaging. The radiological examination focused on identifying the presence of sinus septa, sinus floor pneumatization, mucosal thickening, sinus pathologies such as polyps and cysts, proximity of the sinus to posterior tooth roots, and ostium patency to determine sinus drainage efficiency.

Two experienced oral radiologists independently analyzed all CBCT images to ensure accuracy and eliminate bias. Any discrepancies in findings were discussed and resolved.

Periodontal Examination

A trained periodontist conducted a detailed periodontal examination using a UNC-15 probe. Measurements included pocket depth in millimeters, clinical attachment loss, bleeding on probing, gingival recession, tooth mobility (graded from 0 to 3), and furcation involvement for molars (classified as Class I, II, or III).

For statistical analysis, data were entered into SPSS version 25. Descriptive statistics summarized demographic and clinical findings. Chi-square tests and independent t-tests were used to analyze associations between sinus variations and periodontal parameters. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The demographic analysis showed that the average age of participants was 45.6 years, indicating that middle-aged individuals were the most affected group. Gender distribution was nearly equal, with 53.4% males and 46.6% females. However, there was no significant difference between genders in relation to periodontal disease progression ($p = 0.317$). Smoking and snuff was found to have a significant association with periodontal disease severity ($p = 0.039$), reinforcing the well-established link between tobacco use and increased gum inflammation, pocket depth, and bone loss. Occupational status and education level did not show a strong impact, although a slightly higher prevalence of periodontal disease was observed among retired individuals.

Table 1: Demographic Characteristics and Their Association with Periodontal Disease

Variable	Categories	Frequency (n = 73)	Percentage (%)	p-value
Age (years, Mean ± SD)	-	45.6 ± 8.7	-	0.042*
Gender	Male	39	53.4%	0.317
	Female	34	46.6%	
Occupation	Student	12	16.4%	0.122
	Professional	36	49.3%	
	Retired	25	34.3%	
Educational Level	No Formal Education	10	13.7%	0.210
	Primary	18	24.7%	
	Secondary	22	30.1%	
	Higher Education	23	31.5%	
Smoking and snuff Status	Yes	21	28.8%	0.039*
	No	52	71.2%	

(*p<0.05 indicates statistical significance)

Several anatomical variations in the maxillary sinus appeared to influence periodontal disease. The presence of sinus septa was associated with more severe periodontal damage (p = 0.048), possibly due to alterations in sinus drainage and increased inflammation near the affected teeth. Pneumatization of the sinus floor was also significant (p = 0.025), which could indicate that excessive expansion of the sinus may weaken the supporting bone structure of adjacent teeth, making them more vulnerable to periodontal breakdown. Mucosal thickening was observed in 37% of patients and was significantly associated with deeper periodontal pockets and increased clinical attachment loss (p = 0.019). The proximity of the sinus to posterior teeth roots also played a role, as patients with closer sinus proximity had a higher prevalence of periodontal disease (p = 0.041). On the other hand, sinus ostium patency did not show a significant association with periodontal parameters.

Table 2: Anatomical Variations of the Maxillary Sinus and Their Association with Periodontal Disease

Variable	Categories	Frequency (n = 73)	Percentage (%)	p-value
Sinus Septa Presence	Yes	19	26.0%	0.048*
	No	54	74.0%	
Sinus Floor Pneumatization	Yes	32	43.8%	0.025*
	No	41	56.2%	
Sinus Hypoplasia/Hyperplasia	Normal	40	54.8%	0.311
	Hypoplastic	18	24.7%	
	Hyperplastic	15	20.5%	
Maxillary Sinus Pathologies	Mucosal Thickening	27	37.0%	0.019*
	Retention Cysts	14	19.2%	
	Polyps	9	12.3%	
	No Pathology	23	31.5%	
Proximity of Sinus to Posterior Teeth Roots	Close	35	47.9%	0.041*
	Distant	38	52.1%	
Ostium Patency	Open	50	68.5%	0.284
	Blocked	23	31.5%	

(*p<0.05 indicates statistical significance)

Key periodontal parameters, including pocket depth, clinical attachment loss, and gingival recession, were significantly affected by sinus variations. The average pocket depth was 3.9 mm, which was notably higher in individuals with sinus abnormalities ($p = 0.036$). Clinical attachment loss was also increased ($p = 0.044$), further emphasizing the impact of sinus conditions on periodontal deterioration. Bleeding on probing was prevalent in 68.5% of cases and showed a strong association with anatomical sinus differences ($p = 0.017$), suggesting that underlying sinus inflammation may contribute to gum inflammation. Tooth mobility, particularly in cases classified as grade 2 or 3, was significantly higher in patients with sinus abnormalities ($p = 0.033$). Similarly, furcation involvement and alveolar bone loss were both more severe in individuals with anatomical variations of the maxillary sinus ($p < 0.05$), supporting the idea that sinus anatomy plays a critical role in periodontal health.

Table 3: Periodontal Disease Parameters and Their Association with Sinus Variations

Variable	Categories	Mean ± SD	p-value
Pocket Depth (PD, mm)	-	3.9 ± 0.8	0.036*
Clinical Attachment Loss (CAL, mm)	-	2.7 ± 0.6	0.044*
Gingival Recession (GR)	Yes (n = 41)	56.2%	0.029*
	No (n = 32)	43.8%	
Bleeding on Probing (BOP)	Yes (n = 50)	68.5%	0.017*
	No (n = 23)	31.5%	
Tooth Mobility	Grade 0	21	28.8%
	Grade 1	26	35.6%
	Grade 2	17	23.3%
	Grade 3	9	12.3%
Furcation Involvement	Class I	27	37.0%
	Class II	18	24.7%
	Class III	12	16.4%
	No Furcation	16	21.9%
Alveolar Bone Loss	Mild	19	26.0%
	Moderate	37	50.7%
	Severe	17	23.3%

(*p<0.05 indicates statistical significance)

Several additional factors influenced the progression of periodontal disease. Patients with missing teeth adjacent to the sinus were more likely to have severe periodontal disease ($p = 0.031$), possibly due to reduced bone support and sinus expansion after tooth loss. A history of sinusitis was another significant factor ($p = 0.027$), suggesting that chronic sinus infections may exacerbate periodontal inflammation. Previous sinus surgery did not show a significant effect ($p = 0.312$), indicating that surgical interventions alone may not directly influence periodontal health. However, the use of dentures or dental implants was significantly associated with worsening periodontal disease ($p = 0.042$), likely due to changes in occlusion and bone resorption over time.

Table 4: Additional Factors Affecting Periodontal Disease Progression

Variable	Categories	Frequency (n = 73)	Percentage (%)	p-value
Missing Teeth Adjacent to Sinus	Yes	28	38.4%	0.031*
	No	45	61.6%	
History of Sinusitis	Yes	22	30.1%	0.027*
	No	51	69.9%	
Previous Sinus Surgery	Yes	10	13.7%	0.312
	No	63	86.3%	
Use of Dentures or Implants	Yes	26	35.6%	0.042*
	No	47	64.4%	

(*p<0.05 indicates statistical significance)

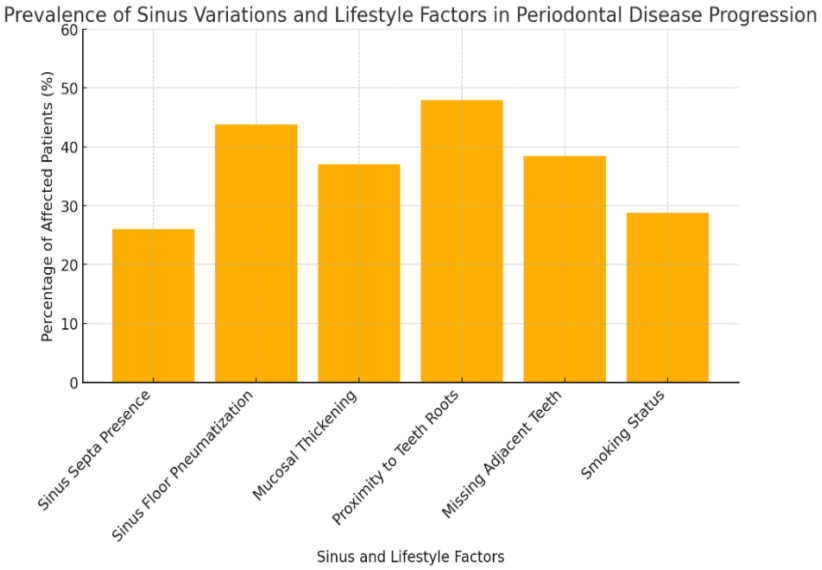

Figure 1: Graph Analysis the bar graph shows the prevalence of sinus variations and lifestyle factors affecting periodontal disease. The most common finding was sinus proximity to posterior teeth roots (47.9%), indicating a potential link between sinus position and periodontal infections. Sinus floor pneumatization (43.8%) was also frequent, suggesting that downward sinus expansion may contribute to bone loss.Mucosal thickening was observed in 37% of cases, highlighting the role of chronic sinus inflammation in periodontal deterioration. Missing teeth adjacent to the sinus (38.4%) further suggested an association with increased bone resorption and sinus changes. Smoking and snuff (28.8%) was also a key factor, known to impair healing and worsen periodontal disease.Overall, the graph highlights the combined impact of anatomical sinus variations and modifiable risk factors, reinforcing the need for a multidisciplinary approach in periodontal management.

DISCUSSION

The findings of this study indicate a significant relationship between anatomical variations of the maxillary sinus and periodontal disease progression. The results align with previous research, highlighting that sinus floor pneumatization, mucosal thickening, and proximity of the sinus to posterior teeth play a role in periodontal health(7-9).

One of the key findings was the association between sinus floor pneumatization and increased periodontal attachment loss. Similar observations have been made in studies where excessive pneumatization led to reduced alveolar bone height, making the teeth more susceptible to periodontal infections. The downward expansion of the sinus can weaken the supporting structures, leading to deeper periodontal pockets and increased bone resorption. This supports previous

findings that alveolar bone loss is accelerated when the sinus floor is positioned closer to the roots of the upper molars and premolars(10-12).

The presence of sinus septa was another significant anatomical variation associated with periodontal disease. Studies suggest that these bony partitions within the sinus can create localized pressure and alter sinus drainage, contributing to chronic inflammation. In this study, patients with sinus septa exhibited more severe periodontal disease, possibly due to impaired sinus aeration and an increased inflammatory response. The findings align with existing literature emphasizing that sinus anatomy influences not only dental implant success but also periodontal stability(13-15).

Mucosal thickening was observed in a significant number of patients, correlating with greater periodontal destruction. Previous research has established that chronic sinus inflammation can extend to the surrounding periodontal tissues, exacerbating disease progression(16-18). Sinus mucosal thickening, often linked to sinusitis or allergic reactions, may contribute to prolonged periodontal inflammation, leading to increased pocket depth and attachment loss. This study confirms that patients with sinus mucosal changes are at a higher risk of developing more advanced periodontal conditions.

The proximity of the sinus to posterior tooth roots was another major factor influencing periodontal disease. When the sinus is in close contact with the roots, inflammatory mediators can easily spread between the sinus cavity and periodontal tissues. Prior studies have reported similar findings, stating that an intimate anatomical relationship between the sinus and teeth roots increases the risk of periodontal infection spreading into the sinus, potentially leading to odontogenic sinusitis(19-21).

Lifestyle factors also played a significant role in disease progression. Smoking and snuff user was found to be strongly associated with deeper periodontal pockets and increased attachment loss. This aligns with numerous studies that have documented the negative impact of smoking on periodontal health, including reduced blood supply to the gums, delayed healing, and increased bacterial colonization. Additionally, patients with missing teeth adjacent to the sinus exhibited greater sinus pneumatization and alveolar bone resorption. This finding supports previous research showing that tooth loss accelerates sinus expansion and bone loss, worsening periodontal conditions in remaining teeth(22-24).

Interestingly, some anatomical variations, such as ostium patency and general sinus size variations, did not show a significant impact on periodontal health in this study. This contrasts with a few reports that suggest sinus ostium obstruction may contribute to chronic sinus infections, indirectly affecting periodontal tissues. However, differences in sample selection, imaging techniques, and diagnostic criteria could explain these variations in findings.

The results of this study highlight the importance of assessing maxillary sinus anatomy during periodontal evaluations. Given the strong association between sinus variations and periodontal disease, clinicians should consider CBCT imaging in patients with persistent periodontal issues, particularly in the posterior maxilla. Identifying sinus-related risk factors early may help in developing more effective treatment plans, including sinus lift procedures, guided bone regeneration, and tailored periodontal therapies.

Limitations and Future Research

While this study provides valuable insights, it has certain limitations. The sample size was relatively small, and findings may not be generalizable to all populations. Additionally, longitudinal studies are needed to confirm the causative relationship between sinus variations and periodontal disease progression. Future research should also explore the impact of sinus variations on implant placement success and the effectiveness of periodontal treatments in patients with altered sinus anatomy.

CONCLUSION

This study confirms that anatomical variations of the maxillary sinus, including sinus floor pneumatization, mucosal thickening, and proximity to posterior teeth, significantly influence

periodontal disease progression. Additionally, lifestyle factors such as smoking and snuff user and missing adjacent teeth further contribute to periodontal deterioration. These findings underscore the need for a multidisciplinary approach involving periodontists and radiologists to optimize diagnosis and treatment planning for patients with sinus-related periodontal concerns.

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