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FREQUENCY OF CONCHA BULLOSA IN PARANASAL SINUSITIS: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Concha bullosa, defined as pneumatization of the middle turbinate, is among the most common anatomical variations of the nasal cavity and is frequently implicated in osteomeatal obstruction. Its presence may alter airflow dynamics and contribute to chronic sinonasal inflammation. Computed tomography (CT) remains the gold standard for identifying such variants, particularly in patients evaluated for sinusitis. Despite extensive international data, local evidence remains limited, highlighting the need for population-specific research.

Objective: To determine the frequency of concha bullosa in patients with radiological evidence of sinusitis on CT imaging.

Methods: A descriptive cross-sectional study was conducted at the Department of Radiology, Islamabad Diagnostic Center, from December 2023 to May 2024. A total of 95 patients aged 18–50 years with CT-confirmed mucosal thickening in at least one paranasal sinus were enrolled through non-probability consecutive sampling. High-resolution CT scans of the paranasal sinuses were performed in standardized planes and evaluated independently by two experienced consultant radiologists to identify the presence of concha bullosa. Demographic characteristics and radiological findings were documented and analyzed using SPSS version 26.0. Associations with gender and age groups were assessed using the Chi-square test, with $p \leq 0.05$ considered significant.

Results: The mean age of the participants was 33.15 ± 9.34 years, with males comprising 62.1% (n=59) and females 37.9% (n=36). Concha bullosa was identified in 41.1% (n=39) of the study population, while 58.9% (n=56) showed no pneumatization. Gender-wise prevalence was 42.4% in males and 38.9% in females, with no significant association ($p = 0.738$). Age-stratified analysis revealed prevalences of 32.4% (18–30 years), 37.9% (31–40 years), and 55.2% (41–50 years), though the increasing trend was not statistically significant ($p = 0.162$).

Conclusion: Concha bullosa emerged as a common anatomical variant in patients with radiological evidence of sinusitis, occurring in over two-fifths of the cohort. Although its distribution showed no significant gender difference, the rising trend with age suggests a potentially dynamic pattern that warrants further longitudinal evaluation. Preoperative CT detection remains essential for surgical planning and optimizing functional endoscopic sinus surgery outcomes.

Keywords: Concha Bullosa; Computed Tomography; Middle Turbinate; Paranasal Sinus Diseases; Radiology; Sinusitis; Turbinates.

INTRODUCTION

The paranasal sinuses play a critical role in upper airway physiology, and even subtle structural variations within the sinonasal complex may predispose individuals to chronic or recurrent disease (1). Sinonasal disorders constitute a significant clinical burden worldwide, often arising from or exacerbated by anatomical variants such as nasal septal deviation, agger nasi cells, Haller cells, anomalies of the uncinate process, and concha bullosa—the latter being the most frequently encountered variant in clinical practice (2). Concha bullosa refers to pneumatization of the middle turbinate, a structure essential for regulating nasal airflow, optimizing ventilation of the osteomeatal complex, and facilitating efficient mucociliary clearance. When excessively pneumatized or hypertrophied, the middle turbinate may compromise sinus drainage, contributing to secretion retention, recurrent maxillary infections, impaired mucociliary transport, and ultimately chronic rhinosinusitis (3-5). Computed tomography (CT) has become the gold standard for evaluating sinonasal anatomy and pathology, offering unparalleled visualization of anatomical variants that may influence disease onset or progression. International studies report the prevalence of concha bullosa to be approximately 44% in the general population, with unilateral presentations occurring more frequently than bilateral involvement (6-8). A consistent positive association has been documented between the presence of concha bullosa and contralateral nasal septal deviation, and many authors have also described a relationship between unilateral or dominant concha bullosa and coexisting sinusitis, particularly when septal deviation is present. These findings underscore the clinical importance of recognizing anatomical variants that may alter airflow dynamics, narrow the osteomeatal complex, or predispose patients to chronic inflammation (9,10). Despite the substantial global literature on sinonasal anatomical variants, there remains a notable absence of comparable data from the Pakistani population. Given anatomical and environmental differences across populations, understanding the local prevalence and clinical impact of concha bullosa is essential for refining diagnostic pathways, guiding surgical planning, and improving patient outcomes. Therefore, the present study aims to determine the frequency of concha bullosa among patients with sinusitis in a Pakistani cohort, providing evidence that may support more tailored and effective management strategies for sinonasal disease. The objective of this study is thus rationalized: to establish population-specific data on concha bullosa prevalence and its relevance in patients presenting with sinusitis.

METHODS

The study employed a descriptive cross-sectional design and was carried out in the Department of Radiology at Islamabad Diagnostic Center, Islamabad, following approval from the Institutional Ethical Review Committee. Data collection took place from December 2023 to May 2024. The primary objective was to determine the frequency of concha bullosa among patients presenting with radiological evidence of paranasal sinusitis on computed tomography (CT). A total sample of 95 patients was obtained. The sample size was calculated using the WHO sample size calculator, applying a 95% confidence level, 10% margin of error, and an anticipated prevalence of 44% for concha bullosa based on findings of a study (4). Participants were selected using non-probability consecutive sampling to ensure feasibility and timely enrollment. Patients of either gender between 18 and 50 years of age were eligible for inclusion if they demonstrated any degree of mucosal thickening in at least one paranasal sinus on CT bone window images and were medically fit to undergo CT scanning. Exclusion criteria encompassed a history of prior sinus surgery, maxillofacial trauma, or craniofacial anomalies, as well as the presence of sinonasal polyps, sinonasal malignancies, odontogenic sinusitis, or comorbid systemic, cardiac, or respiratory conditions that contraindicated CT imaging. These criteria ensured that anatomical variants rather than secondary pathological causes were assessed in relation to sinusitis (6,7).

Informed written consent was obtained from all eligible participants before imaging. High-resolution computed tomography (HRCT) of the nasal cavity and paranasal sinuses was performed in coronal and sagittal planes according to a standardized protocol under the supervision of a qualified radiologist. Each scan was independently interpreted by two consultant radiologists, each possessing a minimum of five years of diagnostic radiology experience. The axillary, frontal, ethmoid, and sphenoid sinuses were examined for mucosal involvement, and concha bullosa was identified as pneumatization of the middle turbinate on coronal bone window images (11,12). To assess potential demographic associations, cases were stratified into predefined age groups (18–30, 31–40, and 41–50 years) and by gender. All collected data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Quantitative variables such as age were summarized as mean ± standard deviation, while qualitative variables including gender and

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presence of concha bullosa were presented as frequencies and percentages. The Chi-square test was employed to evaluate associations between concha bullosa and age groups or gender, with statistical significance set at $p \leq 0.05$. This analytic approach ensured that both distribution patterns and potential demographic correlations were systematically explored.

RESULTS

The study analyzed data from 95 participants to determine the distribution of demographic characteristics and the frequency of concha bullosa among individuals with radiological features of paranasal sinusitis. The overall mean age of the study population was 33.15 ± 9.34 years, with participants distributed across three predefined age categories. Males constituted a larger proportion of the sample (62.1%, n=59), while females accounted for 37.9% (n=36). The mean age showed minimal variation between genders. Concha bullosa was identified in 41.1% (n=39) of the participants. The condition was absent in 58.9% (n=56). Gender-wise stratification demonstrated that 42.4% of males (n=25) and 38.9% of females (n=14) exhibited concha bullosa, with no statistically significant association between gender and the presence of the anatomical variant ($p = 0.738$). Stratification by age indicated that concha bullosa was present in 32.4% of participants aged 18–30 years (n=12), 37.9% of those aged 31–40 years (n=11), and 55.2% of individuals aged 41–50 years (n=16). Although this pattern suggested an increasing trend with advancing age, the association did not reach statistical significance ($p = 0.162$). All numerical findings are presented in full to maintain clarity and transparency.

Table 1: Age and Gender Distribution in Study Sample (n=95)

Gender	Frequency	Percentage	Mean Age Years ± SD
Males	96	68.6	44.30 ± 10.93
Females	44	31.4	43.54 ± 11.15
Total	140	100.0	44.06 ± 10.97

Table 2: Prevalence of Concha Bullosa Stratified by Gender and Age Group

Variable	Category	Total	Concha Bullosa Absent	Concha Bullosa Present	p-value
Overall		95	56 (58.9%)	39 (41.1%)	
Gender	Female	36	22 (61.1%)	14 (38.9%)	0.738
	Male	59	34 (57.6%)	25 (42.4%)	
Age Group (Years)	18-30	37	25 (67.6%)	12 (32.4%)	0.162
	31-40	29	18 (62.1%)	11 (37.9%)	
	41-50	29	13 (44.8%)	16 (55.2%)	

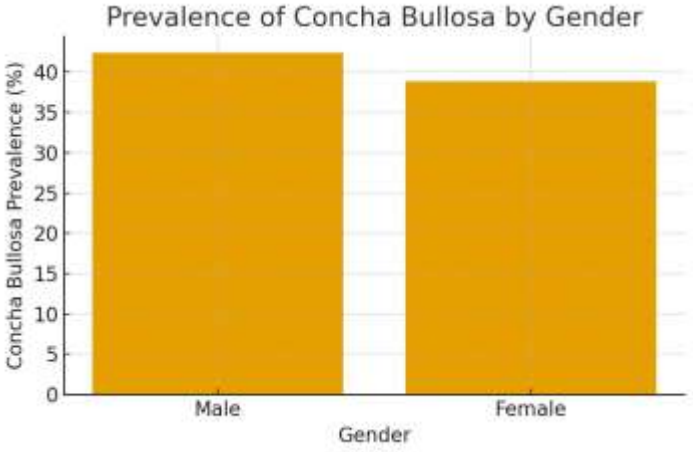

Figure 2 Prevalence of Concha Bullosa by Gender

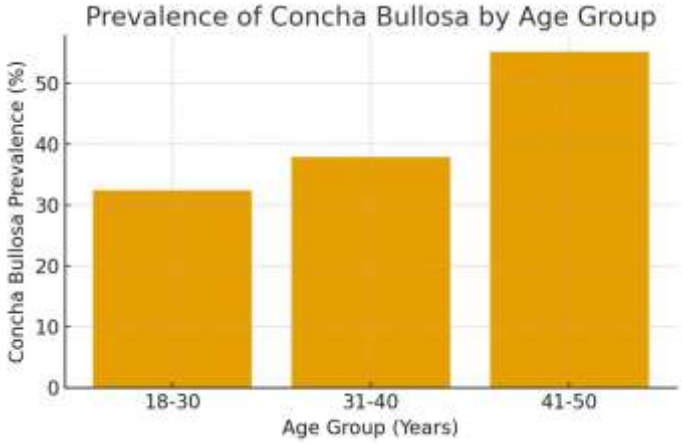

Figure 2 Prevalence of Concha Bullosa by Age Group

DISCUSSION

Concha bullosa, defined as pneumatization of the middle turbinate, represented one of the most frequently encountered anatomical variations in the sinonasal cavity in this study, demonstrating a prevalence of 41.1%. This frequency aligned with the upper range of global reports, which typically describe rates between 15% and 45%, situating the present findings within established epidemiological patterns. Such variability in prevalence across studies is often attributed to differences in diagnostic thresholds, imaging resolution, and ethnic or geographic diversity within study populations. The observed prevalence reaffirmed that concha bullosa is a common anatomical variant encountered during routine radiological evaluation of patients with sinonasal complaints (12,13). Its identification remained clinically pertinent, as the presence of this variant may influence nasal airflow, alter the anatomy of the osteomeatal complex, and predispose patients to obstructive phenomena, especially in those undergoing evaluation for chronic rhinosinusitis or planned endoscopic sinus surgery (14,15). In the current study, concha bullosa was slightly more common in males than females, though the difference was not statistically significant. This finding paralleled the majority of published literature, where pneumatization of the middle turbinate has not demonstrated any consistent gender predilection. The lack of sex-linked variation aligned with established developmental understanding, as pneumatization typically progresses during adolescence and early adulthood, independent of known hormonal influences (16,17). The age-stratified analysis revealed a progressive increase in the prevalence of concha bullosa with advancing age, reaching 55.2% in the 41–50-year age group. Although the association did not achieve statistical significance, the trend warranted attention. The pattern raised the possibility that the degree of pneumatization may evolve over time rather than remain a static congenital anomaly. Observations from various studies have suggested that chronic inflammatory remodeling, prolonged mucosal exposure to allergens, and incremental structural changes may contribute to the radiological prominence of concha bullosa in older individuals (18). This perspective introduced a clinically meaningful hypothesis that pneumatization may be a dynamic process influenced by environmental and inflammatory factors throughout adulthood.

From a pathophysiological standpoint, concha bullosa has long been implicated in the development of sinonasal disease through its potential to narrow the osteomeatal complex, impair mucociliary clearance, and disrupt regional airflow patterns. Several studies have documented a higher burden of maxillary and ethmoid sinusitis in individuals with large or bilateral conchae bullosae. However, the present study did not identify statistically significant associations between concha bullosa and demographic variables. This finding aligned with large-scale analyses that argue concha bullosa may function more as an incidental radiological finding when small or non-obstructive. Conversely, other studies have demonstrated a strong correlation between concha bullosa and septal deviation or sinusitis, particularly when the variant was extensive (19,20). A critical clarification has emerged across the literature: the clinical significance of concha bullosa depends not merely on its presence but on its size, extent, and resulting mechanical impact. This interpretation reconciles the divergent conclusions in the literature and frames concha bullosa as a potentially variable contributor to sinonasal pathology rather than a universal causative factor (21). The present study contributed meaningfully to this ongoing debate by situating its findings within the context of regional data. The prevalence documented here was consistent with global patterns, yet the lack of significant associations

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with age or gender suggested that demographic factors alone may not fully explain the development or clinical expression of this variant (22). A notable strength of this study was the use of high-resolution CT imaging interpreted by experienced radiologists, ensuring accuracy in identifying anatomical variants. Additionally, the stratified analysis allowed for the exploration of potential demographic influences, even where statistical significance was not achieved. The structured inclusion and exclusion criteria further strengthened internal validity by minimizing confounding due to prior surgeries, trauma, or sinonasal malignancies.

However, several limitations deserved consideration. The cross-sectional design restricted the ability to infer causation, particularly regarding the potential age-related progression of pneumatization. Although the sample size was adequate for gender-based analysis, it may have been underpowered to detect subtle yet meaningful trends across age groups. Furthermore, the study did not correlate radiological findings with clinical parameters such as symptom severity, history of rhinosinusitis, or endoscopic findings. The absence of morphological characterization of concha bullosa—such as its size or classification—also limited the ability to assess its true clinical relevance, as larger or extensive variants are more likely to contribute to obstruction. Additionally, inter-observer variability, although minimized by dual radiologist review, was not measured quantitatively. Despite these limitations, the findings added valuable insight into the regional prevalence and demographic distribution of concha bullosa. The observed age-related trend, although not statistically conclusive, opened avenues for further investigation into the developmental trajectory of this variant. Future research should incorporate larger and more diverse populations, integrate clinical symptomatology, and include detailed morphological assessment to determine whether size or type of concha bullosa contributes to disease burden (23). Longitudinal or retrospective cohort designs may better elucidate whether pneumatization continues to evolve with age and whether such progression carries clinical consequences. Clearer understanding could refine diagnostic frameworks, enhance preoperative planning, and improve patient selection for targeted surgical interventions. Overall, the study reinforced the recognition of concha bullosa as a common anatomical variant with potential—though variable—clinical relevance. By contributing population-specific data and highlighting the importance of imaging-based anatomical assessment, it provided groundwork for more nuanced and clinically meaningful research on sinonasal anatomical variations.

CONCLUSION

This study reinforces that concha bullosa is a frequently encountered anatomical variant among Pakistani patients with radiological features of sinusitis and highlights its continued relevance in clinical evaluation. The lack of gender association supports existing evidence that its development is not sex-linked, while the observed age-related trend suggests that concha bullosa may not be entirely static across the lifespan. Its consistent detection on CT imaging underscores its practical importance in preoperative planning for functional endoscopic sinus surgery, where awareness of anatomical variations is essential for minimizing complications and improving surgical outcomes. These findings emphasize the need for future work exploring how the size and morphology of concha bullosa relate to symptom severity, potentially advancing understanding of its role in chronic sinonasal disease.

AUTHOR CONTRIBUTION

Author	Contribution
Mechale Sana Balouch*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Shamrez Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Mohammad Moaz Balouch	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

Author	Contribution
Muhammad Aitzaz Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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