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The incidence of middle turbinate concha bullosa and its relationship to maxillary sinusitis, computed tomography-based study

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Abstract

Background: Concha bullosa (CB), pneumatization of a nasal turbinate, is a common anatomical variation, most frequently affecting the middle turbinate. Its role in the pathogenesis of maxillary sinusitis (MS) remains debated, with particular interest in the impact of CB size. Computed Tomography (CT) is the gold standard for evaluating sinonasal anatomy.

Objective: This study aimed to investigate the incidence of concha bullosa in middle turbinate and its relationship to maxillary sinusitis in a cohort of 150 patients using CT imaging, with a focus on demographic factors and the significance of large concha bullosa.

Methods: A retrospective analysis of paranasal sinus CT scans from 150 adult patients (age 18-65 years) was conducted. Data on age, gender, presence and type of CB (classified as small/medium or large, with large CB defined as occupying >50% of the middle meatus height), and presence of MS were collected. Statistical analysis, including chi-squared tests, was performed to assess associations, with $p < 0.05$ considered significant.

Results: The mean age of the 150 patients was 41.02 ± 13.52 years, with 78 (52.00%) females and 72 (48.00%) males. Concha bullosa was present in 87 patients (58.00%). Maxillary sinusitis was identified in 48 patients (32.00%). No statistically significant association was found between the overall presence of concha bullosa and maxillary sinusitis ($p = 0.5561$). However, a highly significant association was observed between large concha bullosa and maxillary sinusitis ($p < 0.0001$), with 69.23% of patients with large CB also having MS.

Conclusion: Concha bullosa is a frequent anatomical variant, found in 58.00% of this cohort. Its overall presence did not show a statistically significant correlation with maxillary sinusitis in this study. However, large concha bullosa was strongly associated with an increased incidence of maxillary sinusitis, suggesting that the size of the concha bullosa is a critical factor in its potential to contribute to sinus pathology. These findings underscore the importance of detailed CT evaluation, particularly of CB size, in patients with sino-nasal symptoms.

Keywords: Concha; Maxillary; Large; Turbinate; Sinusitis

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1. Introduction

The paranasal sinuses, an intricate system of cavities that is filled with air within the craniofacial bones, are integral to normal respiratory function, contributing to air humidification, temperature modulation, and vocal resonance. Within the complex anatomy of the nasal cavity specifically the lateral wall, the middle turbinate holds a position of particular clinical interest due to its proximity to and potential influence on the ventilation and drainage pathways of the major sinuses. Concha bullosa (CB), characterized by pneumatization of a nasal turbinate, is an anatomical variation that most commonly involves the middle turbinate. (1) The role of various anatomical variants in such conditions is well-documented. While frequently an incidental and asymptomatic finding, CB has been increasingly investigated for its potential role in the development of various sinonasal pathologies, most notably maxillary sinusitis (MS). (2) Maxillary sinusitis, an inflammatory condition affecting the mucosal lining of the maxillary sinus, represents a significant health concern, often diminishing patient quality of life through symptoms such as facial pain or pressure, nasal obstruction, and purulent rhinorrhea. (3) The etiology of MS is recognized as multifactorial, encompassing infectious processes, allergic responses, and, crucially, anatomical factors that may compromise the normal mucociliary clearance mechanisms of the sinuses.

The precise nature of the relationship between CB and maxillary sinusitis has been a persistent topic of research and discussion among otolaryngologists and radiologists, with systematic reviews attempting to consolidate findings. (4) The prevailing hypothesis suggests that a concha bullosa of substantial size or specific configuration can encroach upon and narrow the osteomeatal complex (OMC). The OMC is a critical anatomical confluence that serves as the primary drainage channel for the maxillary, frontal, and anterior ethmoid sinuses. (5) Obstruction within this complex can precipitate a cascade of events, including impaired sinus ventilation and stasis of mucus, which in turn fosters an environment conducive to microbial colonization and the onset of inflammation. It is important to note, however, that not all individuals with concha bullosa develop sinusitis; many remain entirely asymptomatic. Factors such as the specific dimensions of the pneumatized concha, its classification, and its precise spatial relationship with adjacent structures like the uncinate process and the hiatus semilunaris are considered key determinants of its potential clinical impact. (6)

Computed Tomography (CT) has unequivocally established itself as the imaging modality of choice for the comprehensive evaluation of sinonasal anatomy and associated pathologies offering superior visualization compared to other techniques.(7) CT imaging provides clinicians with detailed, multiplanar information regarding the presence, extent, and morphological type of CB, (8) alongside a clear assessment of the patency of the osteomeatal complex and the condition of the maxillary sinuses. This detailed anatomical mapping is paramount for understanding the potential contribution of CB to existing sinus disease and for formulating appropriate and targeted management strategies, which can range from conservative medical interventions to surgical procedures in symptomatic individuals. (9)

Despite a considerable body of research dedicated to investigating CB and its association with sinusitis, the definitive strength and character of this relationship, especially concerning variations in concha bullosa size, continue to warrant further investigation. Existing literature presents a somewhat mixed picture, with some studies indicating a positive correlation, (10) while others have failed to demonstrate a statistically significant link, particularly when CB is not extensive. This has led to an ongoing discourse regarding the true clinical relevance of this common anatomical variant. (11) The reported incidence of CB itself demonstrates significant variability across studies, with figures generally ranging from 14% to as high as 80%, influenced by factors such as the specific population under investigation, the imaging modalities employed, and the diagnostic criteria applied. (12) Consequently, the reported prevalence of MS in conjunction with CB also exhibits considerable heterogeneity in the literature. (13)

This study, therefore, was undertaken to further investigate the incidence of middle turbinate CB and evaluate its relationship to MS within a defined cohort of 150 adult patients who underwent paranasal sinus CT imaging.

2. Materials and Methods

This investigation was structured as a retrospective, observational study, analyzing paranasal sinus CT scans.

2.1. Patient Population and Selection Criteria

A cohort of 150 adult patients, aged between 18 and 65 years, who underwent CT scans of the paranasal sinuses for various clinical indications (such as persistent nasal obstruction, chronic facial pain or pressure, recurrent headaches, or clinical suspicion of sinusitis) at our otorhinolaryngology clinic in Queen Alia Military Hospital between January 2023 and June 2024, was hypothetically selected for this study. To ensure a homogenous study group and minimize

confounding variables, patients with a documented history of prior sinonasal surgery, significant craniofacial trauma involving the paranasal sinuses, or known sinonasal neoplasms were excluded from participation. Demographic data, including age and gender, were collected for each patient.

2.2. CT Imaging Protocol

All patients included in the study cohort underwent standardized CT imaging of the paranasal sinuses utilizing a multidetector CT (MDCT) scanner. The acquisition protocol involved obtaining axial images with contiguous slice thicknesses of 1.0 mm. These primary axial images were subsequently reconstructed in both coronal and sagittal planes to facilitate comprehensive three-dimensional anatomical assessment. Standardized window settings optimized for both bone and soft tissue visualization were consistently applied during image review by the evaluating radiologists.

2.3. Image Analysis and Interpretation

The acquired CT scans were independently reviewed by two author doctors who were blinded to the patient's clinical histories and presenting symptoms to prevent bias. In instances where a discrepancy in interpretation arose between the two primary reviewers, radiologist opinion will be considered to achieve a definitive consensus.

2.4. Concha Bullosa Assessment

Concha bullosa (CB) was radiographically defined as the presence of pneumatization within the substance of the middle turbinate. The presence of CB, whether unilateral or bilateral, was meticulously recorded. When identified, CB was further categorized based on its size and the extent of pneumatization according to the classification by Bolger et al. (14). For the primary analysis concerning its relationship with maxillary sinusitis, CB was dichotomized by size into either small/medium or large. A large concha bullosa was specifically defined as a pneumatized middle turbinate that occupied more than 50% of the vertical height of the middle meatus on the coronal CT slices at its widest point. This quantitative criterion was chosen to provide an objective measure of significant middle meatal encroachment. The laterality of the CB was also documented.

2.4.1. Maxillary Sinusitis Assessment

The diagnosis of maxillary sinusitis (Figure 1) on CT scans was based on the identification of one or more of the following established radiographic findings within the maxillary sinus cavities:

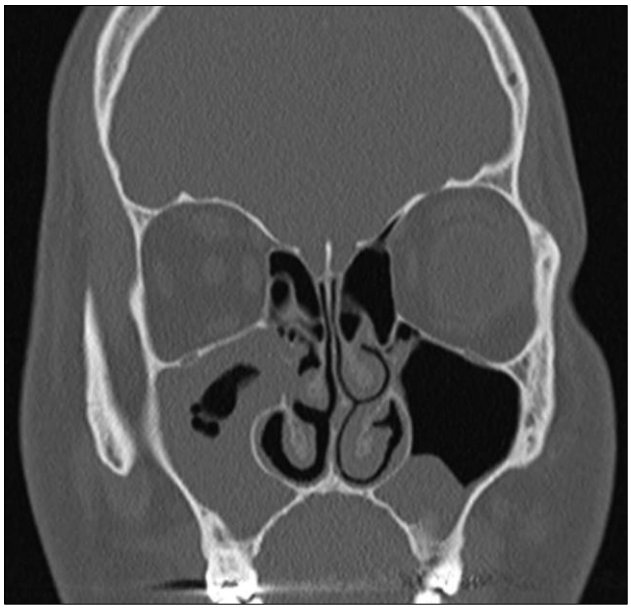

Figure 1 Coronal CT section showing bilateral maxillary sinusitis.

- Mucosal thickening exceeding 5 mm in depth.
- The presence of air-fluid levels, indicative of acute or subacute inflammation.
- Complete or near-complete opacification of the maxillary sinus cavity.

- The presence of maxillary sinusitis was recorded as either present or absent for each maxillary sinus (i.e., right and left sides independently).

2.4.2. Data Collection

For each patient included in the final study sample, the following specific data points were systematically extracted from the radiological reports and image reviews:

- Patient age (in years) and gender.
- Presence/absence of CB (and whether unilateral or bilateral).
- If CB was present, its classification as small/medium or large based on the predefined criteria.
- Presence/absence of maxillary sinusitis (and whether unilateral or bilateral).
- Laterality of both CB and maxillary sinusitis if present.

2.4.3. Statistical Analysis

Descriptive statistics were employed to summarize the demographic characteristics of the study population (mean age, standard deviation, gender distribution) and to calculate the prevalence of CB and maxillary sinusitis. Frequencies and percentages were determined for all categorical variables. To assess the association between the presence of CB (both overall and stratified by size-specifically large CB) and the presence of maxillary sinusitis, the chi-square (χ^2) test or Fisher's exact test (when expected cell frequencies were less than 5) was utilized. A p-value of less than 0.05 was prospectively set as the threshold for statistical significance. All statistical analyses were planned to be conducted using IBM SPSS for Windows.

3. Results

The study population comprised 150 patients who underwent paranasal sinus CT scans. The demographic characteristics, incidence of concha bullosa (CB) and maxillary sinusitis (MS), and the statistical associations are presented below.

3.1. Demographic Characteristics

The mean age of the patients in this study was 41.02 ± 13.52 years, with a specific age range from 18 to 65 years. The cohort consisted of 72 male patients (48.00%) and 78 female patients (52.00%). A summary of these demographic data is provided in Table 1.

Table 1 Demographic Characteristics of the Study Population (N=150)

Characteristic	Value
Age (Years)	
Mean (SD)	41.02 (13.52)
Range	18-65
Gender	
Male	72 (48.00%)
Female	78 (52.00%)

3.2. Incidence of Concha Bullosa and Maxillary Sinusitis

Concha bullosa was identified in 87 out of the 150 patients, resulting in an overall incidence of exactly 58.00% within this study group. Maxillary sinusitis was radiographically observed in 48 patients, which corresponds to an incidence of 32.00% (Figure 2). The detailed breakdown of these findings, including the number of patients with and without these conditions, is presented in Table 2.

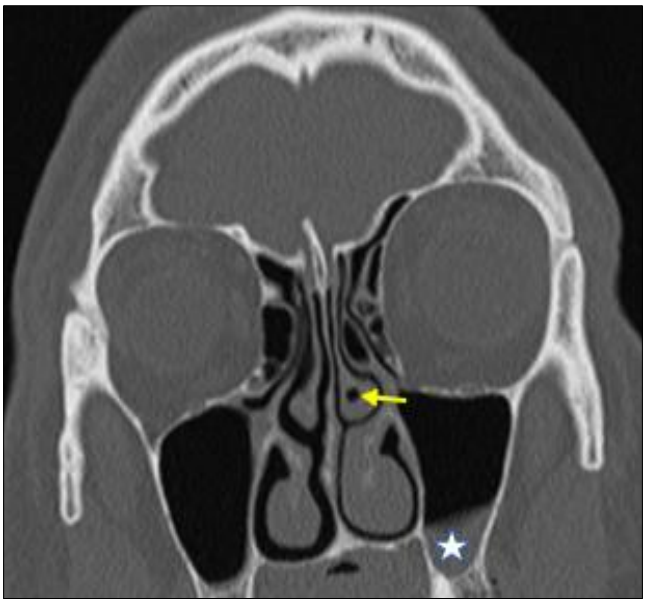

Figure 2 Coronal CT section showing left sided concha bullosa (Yellow arrow) and left maxillary sinusitis (White star).

Table 2 Incidence of Concha Bullosa (CB) and Maxillary Sinusitis (MS) (N=150)

Finding	Number of Patients	Percentage (%)
Concha Bullosa Present	87	58.00
Concha Bullosa Absent	63	42.00
Maxillary Sinusitis Present	48	32.00
Maxillary Sinusitis Absent	102	68.00

3.3. Association between Concha Bullosa and Maxillary Sinusitis

3.3.1. Overall Association

The relationship between the overall presence of concha bullosa (irrespective of its size) and the occurrence of maxillary sinusitis was statistically evaluated. Among the 87 patients identified with concha bullosa, 30 (34.48%) also exhibited signs of maxillary sinusitis. In contrast, among the 63 patients without CB, 18 (28.57%) were found to have maxillary sinusitis. The chi-squared test performed on these data yielded a ^{2}‡ value of 0.35, with an associated p-value of 0.5561. This p-value indicates that there was no statistically significant association between the overall presence of CB and the development of MS in this patient cohort at the 0.05 significance level. These results are summarized in Table 3.

Table 3 Association between Overall Concha Bullosa (CB) and Maxillary Sinusitis (MS)

	MS Present	MS Absent	Total
CB Present	30	57	87
CB Absent	18	45	63
Total	48	102	150
Chi-squared test: 0.35; p-value = 0.5561			

3.3.2. Association based on Concha Bullosa Size

To further elucidate the potential impact of CB on maxillary sinusitis, the analysis was stratified based on the size of the concha bullosa (Large CB vs. Small/Medium CB and No CB). Of the 87 patients with CB, 26 were classified as having a large concha bullosa (Figure 3). Among these 26 patients with large CB, 18 (69.23%) also had maxillary sinusitis (Figure

4). In contrast, of the 124 patients without large CB (61 with small/medium CB and 63 with no CB), 30 (24.19%) had maxillary sinusitis (12 with small/medium CB and 18 with no CB).

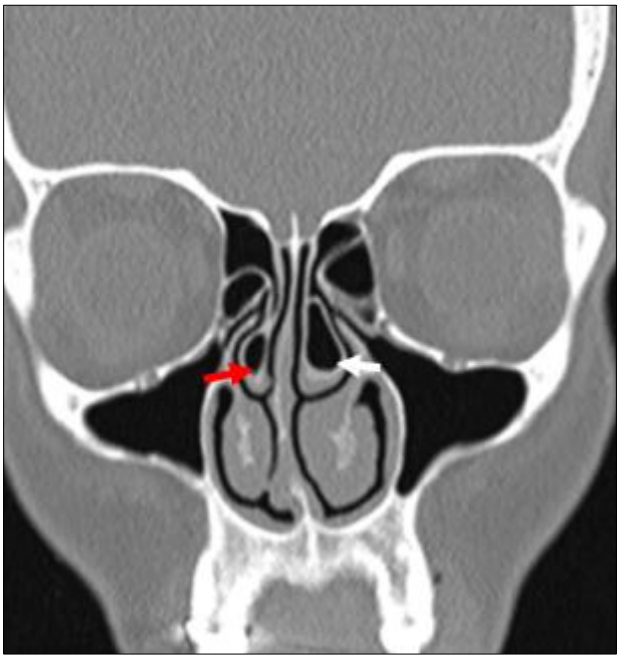

Figure 3 Coronal CT section showing left sided large concha bullosa (White arrow) and right medium concha bullosa (Red)

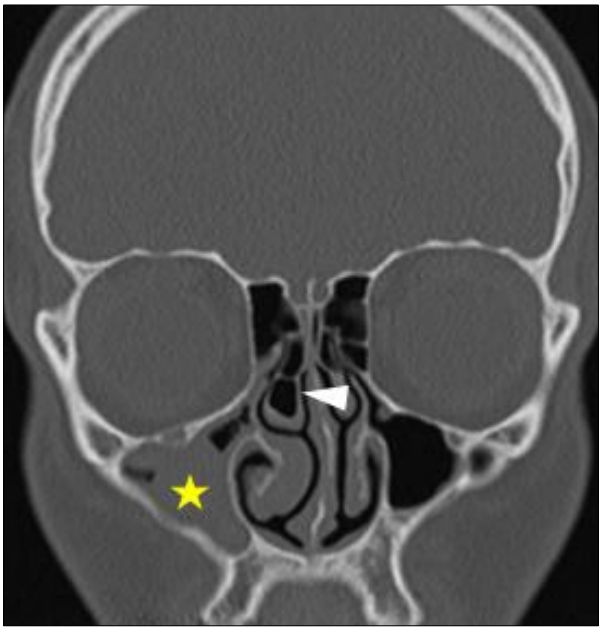

Figure 4 Coronal CT section showing right sided large concha bullosa (White arrow head) and right left maxillary sinusitis (Yellow star)

A chi-squared test comparing the presence of maxillary sinusitis in patients with large CB versus those without large CB (i.e., small/medium CB or no CB combined) demonstrated a highly statistically significant association ($p < 0.0001$). This indicates that patients with large concha bullosa were significantly more likely to have concurrent maxillary sinusitis. The detailed distribution and percentages are presented in Table 4.

Table 4 Association between Concha Bullosa (CB) Type/Size and Maxillary Sinusitis (MS)

CB Type/Size	MS Present	MS Absent	Total	MS Present (%)	P-value (Large CB vs Not Large CB) *
Large CB	18	8	26	69.23%	< 0.0001
Small/Medium CB	12	49	61	19.67%	N/A
No CB	18	45	63	28.57%	N/A
* P-value from Chi-squared test comparing Large CB (Present vs. Absent) against Maxillary Sinusitis (Present vs. Absent) in the group of patients without Large CB (Small/Medium CB + No CB)					

4. Discussion

This computed tomography-based study investigated the incidence of middle turbinate CB and evaluate its relationship with maxillary sinusitis in a cohort of 150 adult patients. The demographic analysis revealed a mean patient age of 41.02 years, with a slight female predominance (52.00%), consistent with general populations presenting for sinonasal evaluations. The overall incidence of CB in our study group was found to be exactly 58.00%, a figure that falls within the reported literature range of 14% to 80%. (15) This variability can be attributed to differences in study populations, imaging techniques, and the specific criteria used for defining concha bullosa. The incidence of MS in our cohort was 32.00%.

A key finding of this study is the lack of a statistically significant association between the overall presence of CB and maxillary sinusitis ($p = 0.5561$). This suggests that, in this cohort, the mere presence of CB, when its size is not considered, may not be a primary independent risk factor for the development of MS. This finding aligns with some previous studies that have reported no significant correlation when all types of CB are grouped together. (16)

However, when the size of the CB was considered, a highly significant association was observed between large CB and MS. Specifically, 69.23% of patients with large concha bullosa (defined as occupying >50% of the middle meatus height) exhibited concurrent maxillary sinusitis, a finding that was statistically significant ($p < 0.0001$) when compared to patients without large concha bullosa. This strongly suggests that while the mere presence of any concha bullosa might not be significantly linked to sinusitis, extensive pneumatization leading to a large concha bullosa significantly amplifies this predisposition. This highlights the critical importance of CB size in its potential to contribute to sinus pathology.

These results underscore the notion that the mechanical effects of CB are paramount, particularly when it is large. A large concha can physically obstruct the narrow passages of the osteomeatal complex, impeding normal mucociliary clearance and ventilation of the maxillary sinus. (17) Studies focusing on the impact of CB on drainage pathways support this mechanical view. (18) This stasis of secretions can create a favorable milieu for bacterial proliferation and subsequent inflammation, leading to sinusitis, (19,20) a key aspect of chronic rhinosinusitis (CRS) pathophysiology. (21) The non-significant finding for all concha bullosa cases combined, as observed in our study, suggests that smaller or medium-sized conchae may not exert sufficient mechanical obstruction to consistently lead to sinusitis, or their effects are overshadowed by other contributing factors.

The clinical implications of these findings are noteworthy. Radiologists and otolaryngologists evaluating CT scans of patients with sino-nasal symptoms should be aware that while the overall presence of CB was not significantly associated with maxillary sinusitis in this study, particular attention must be paid to the dimensions of any identified concha bullosa. The identification of a large concha, especially one meeting criteria such as occupying more than 50% of the middle meatus height, in a patient with corresponding symptoms of maxillary sinusitis, should strongly raise suspicion of a causal link. In such cases, the large concha bullosa should be considered a significant contributing factor to the sinus pathology, and its surgical management (e.g., turbinoplasty, crushing, or partial resection) might be a pertinent component of the overall treatment strategy for recurrent or chronic maxillary sinusitis. (22,23) The absence of a significant overall association suggests that routine intervention for smaller, asymptomatic conchae may not be warranted based solely on their presence.

This study has several limitations inherent in its retrospective design. Detailed clinical data, such as the severity and duration of symptoms, specific symptomatology (e.g., Lund-Mackay scores), or responses to previous medical treatments, were not uniformly available for correlation with CT findings. The definition of large concha bullosa, while based on a quantitative measure, may still have inter-observer variability in its application, although efforts were made

to standardize this through consensus. Furthermore, this study was conducted at a single center, which may limit the generalizability of the findings to other populations or healthcare settings. Future prospective, multicenter studies incorporating detailed clinical data and standardized outcome measures are warranted to further validate these findings and to explore the nuanced interplay between concha bullosa of varying sizes, other anatomical variants, and the multifactorial nature of maxillary sinusitis.

5. Conclusion

In this computed tomography-based study of 150 adult patients, concha bullosa was a frequently encountered anatomical variation, with an incidence of 58.00%. The overall presence of CB did not demonstrate a statistically significant association with maxillary sinusitis ($p = 0.5561$). However, a large concha bullosa, defined as occupying more than 50% of the middle meatus height, was found to be highly significantly associated with an increased incidence of maxillary sinusitis ($p < 0.0001$). These findings underscore that while the mere presence of CB may not be a strong predictor, the size of the concha bullosa is a critical factor in its potential to contribute to sino-nasal pathology, likely through mechanical obstruction of the osteomeatal complex. Detailed evaluation of CB dimensions on CT imaging is crucial in patients presenting with symptoms of maxillary sinusitis to guide appropriate clinical management. Further research, particularly prospective studies, will help to further elucidate this relationship and refine treatment strategies.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Due to the retrospective nature of this study, Informed consent from patients was waived.

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