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The "Structural Interplay": Deviated Septal Angle and Pneumatization of Bulla - A Retrospective Study

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ABSTRACT

Introduction: Concha bullosa (CB) refers to the pneumatization of the concha, typically the middle turbinate. The precise mechanism of the CB remains ambiguous; nonetheless, the airflow pattern within the nasal cavity is deemed to be significant. The reduced airflow in the nasal cavity, due to the convexity of the deviation, results in increased pneumatization. While clinical practice findings typically support this, there is insufficient quantitative research validating the association between the angle of deviation and the degree of pneumatization.

Objective: 1. To estimate the association of concha bullosa in cases with septal deviation;

2. To find the relationship between the angle of deviation and degree of pneumatization.

Methods: This is a retrospective study conducted in R.L. Jalappa Hospital conducted between Jan 2023-Nov 2024. Around 157 CT scans were studied by convenience sampling. Then nasal septal angle and Pneumatisation index was recorded. The data collected were analysed using Epi info 7.

Results: Among 157 paranasal CT scans analysed, the majority were males aged 20–40 years. Isolated septal deviation (29.9%) was the most common finding, followed by combined concha bullosa with septal deviation (24.8%). Laterality differences were significant, with unilateral CB predominating in CB + SD cases (P = 0.046). Mean septal deviation angles significantly differed across groups (P = 0.0001), while CBPI values showed no significant variation between subgroups.

Conclusion: Our study concludes that bilateral concha bullosa is common in isolated CB cases and unilateral CB is most common in CB with S.D cases. Also mean septal deviation is higher in unilateral septal deviation with CB compared to bilateral one.

Keywords: *Deviated nasal septum, Naso septal angle, Concha bullosa, middle turbinate*

1. INTRODUCTION

The nasal cavity is an asymmetrical compartment situated between the roof of the oral cavity and the cranial base, partitioned by a median vertical septum and composed of bony and cartilaginous structures. The septum comprises of perpendicular plate of the ethmoidal bone superiorly and the vomer, palatine bone, and crest of the maxilla, along with the septal cartilages, inferiorly. It is the relevant anatomical midline component that provides essential support for the nasal cavity.

Deviated nasal septum (DNS) is very common, with estimates ranging between 20% and 80% of the general population. Despite being common, only a subset of individuals developed symptoms severe enough to seek medical attention or require septoplasty. Higher rates are often found in studies using imaging (CT scans) compared to clinical examination.There is no absolute universally agreed threshold, but,deviation >10–15 degrees from the midline is often considered clinically significant.

Deviation causing 50% or more obstruction of the nasal passage on one side may result in notable symptoms.Functional impact, rather than just angle, is more important—e.g., degree of obstruction, airflow reduction, or associated sinus pathology.Compensatory hypertrophy of the inferior turbinate is commonly associated with septal deviation.The contralateral turbinate often undergoes hypertrophy to balance airflow resistance.Chronic septal deviation can cause mucosal and bony hypertrophy of the turbinates.Turbinate hypertrophy contributes to nasal obstruction and may persist even after septoplasty if not addressed. Combined septoplasty and turbinate reduction is often performed to optimize nasal airflow. Any alteration in the structure of the nasal septum alters airflow and impacts mucociliary clearance within the nasal cavity [1–3]. Each side of the nasal cavity contains a superior, middle, and inferior concha. The ethmoidal turbinates originates from ridges in the lateral wall of nose in 9th to 10th week of Intrauterine life. The middle concha may start to become pneumatized at this juncture by the posterior ethmoid air cells at 9 years of age. The CT scan reveals an air void within the middle turbinate, encircled by an oval bone rim [1].

Concha bullosa (CB) refers to the pneumatization of the concha, typically the middle turbinate, originating from posterior ethmoid air cells. Concha bullosa is the most prevalent anatomical variant of the osteomeatal complex and has an incidence ranging from 13% to 53.6% [4]. The precise mechanism of the CB remains ambiguous; nonetheless, the airflow pattern within the nasal cavity is deemed to be significant. The notion termed ''e vacuo'' delineates the link between SD and CB [5]. The reduced airflow in the nasal cavity, due to the convexity of the deviation, results in increased pneumatization of the middle turbinate on the opposite side. While clinical practice findings typically support this reality, there is insufficient quantitative research in our population validating the association between the angle of deviation and the degree of pneumatization in the literature.

Few researches have examined this link and associated the angle of nasal septal deviation (NSD) with the extent of concha bullosa (CB) pneumatization, concluding that NSD does not induce the formation of a CB but may enhance the pneumatization of the middle turbinate, contingent upon the degree of the NSD angle. [6] Several have posited that the NSD does not arise directly from the mass effect of the CB, as air passages remain intact between the nasal septum and the CB[7]. However, there is little evidence regarding the possibility that NSD or pneumatization of the middle turbinate may act as a potential contributor to maxillary sinus volume changes and subsequent sinus pathology[8].

A study revealed that 80% of subjects had NSD, whereas 61.6% demonstrated CB, signifying a substantial prevalence of both diseases.[6] Another study indicated that 77.2% of individuals displayed both CB and NSD, with a notable inclination for NSD to diverge from the predominant CB. The existence of CB and NSD may impair sinus outflow, potentially resulting in chronic sinusitis. [7,8] Nevertheless, certain investigations indicated no substantial link between these polymorphisms and the severity of chronic sinusitis, implying that although they coexist, they may not directly affect sinus disease[9] .A study quoted that a theory named "e vacuo" and gives an explanation relevant to septal deviation .As the airflow is markedly diminished in the nasal cavity with convexity of the deviation , pneumatization, of the middle turbinate is augmented in the contralateral site [10].This study is conducted to fulfill the lacuna in the previous studies

OBJECTIVES

1. To estimate the association of concha bullosa in cases with septal deviation;
2. To find the relationship between the angle of deviation and degree of pneumatization.

2. METHODOLOGY

This is a retrospective study conducted in Dept of Otorhinolaryngology and Head & Neck , between Jan 2023-Nov 2024. Around 157 patients who underwent CT scans of paranasal sinus before surgery was included after obtaining approval from institutional ethics committee

Inclusion criteria: All patients aged between 18- 65 years who underwent CT scans of paranasal sinus before surgery was included.

Exclusion criteria: Previous history of nasal or paranasal sinus surgery

CT scan was taken by standard protocol for various nasal and sinus pathologies. The CT scans were categorized into four groups: Isolated SD, Isolated CB, Coexistence of CB and SD (CB + SD) and Normal scans with no SD or CB. The most markedly deviated sections of the nasal septum were selected for analysis. The deviation angles were calculated using free

DICOM image viewer software. The deviation angle was defined as the angle between the crista galli and the most prominent point of the deviation. The degree of CB was measured using a method known as the Concha Bullosa Pneumatization Index (CBPI), which was previously defined by Uygur et al [6]. This index allowed for a standardized assessment of CB pneumatization.

CBPI = [Area of concha pneumatization(mm$^{2)}$/Area of orbit on the same site(mm$^{2)}$] x 100

The collected data was entered in Microsoft excel and was analysed using Epi info 7. The categorical variable was expressed in proportion and continuous variable were expressed in mean with standard deviation. The unpaired t test and ANOVA was used to compare means

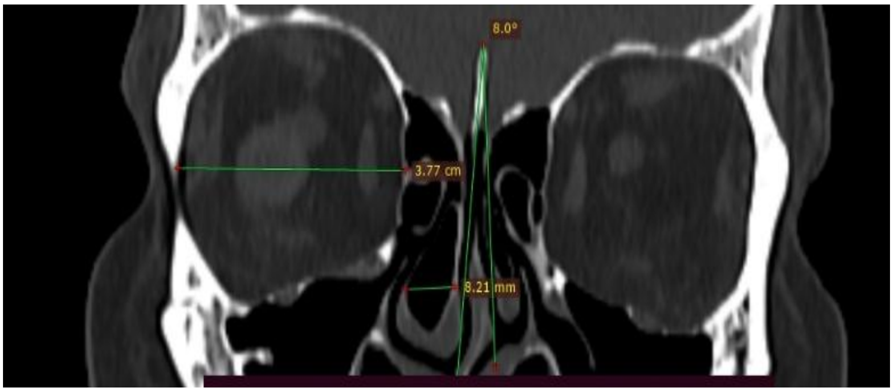


Fig 1: Method of septal deviation measurement with computer-based photo program. The angle between crista galli and the most prominent point of the deviation was accepted as the angle of deviation. Concha bullosa pneumatization index measurement with computer-based photo program. Largest segment of the CB was measured and compared with the ipsilateral orbital area in the same scan. The orbital area represents the hypodense region encircled by sclerotic orbital rim.

Figure 2: Septal deviation with unilateral conchabullosa

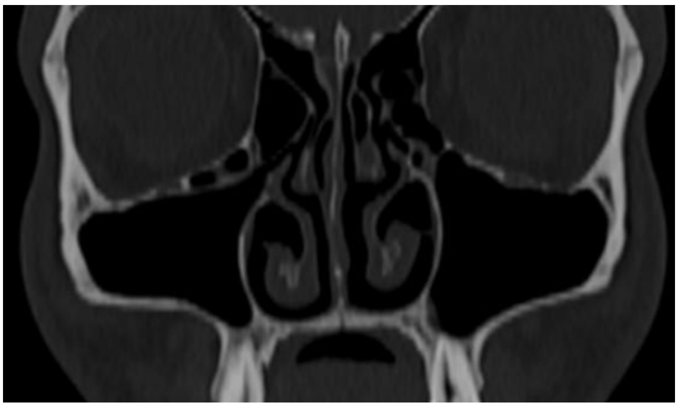


Figure 3: Lamellar type

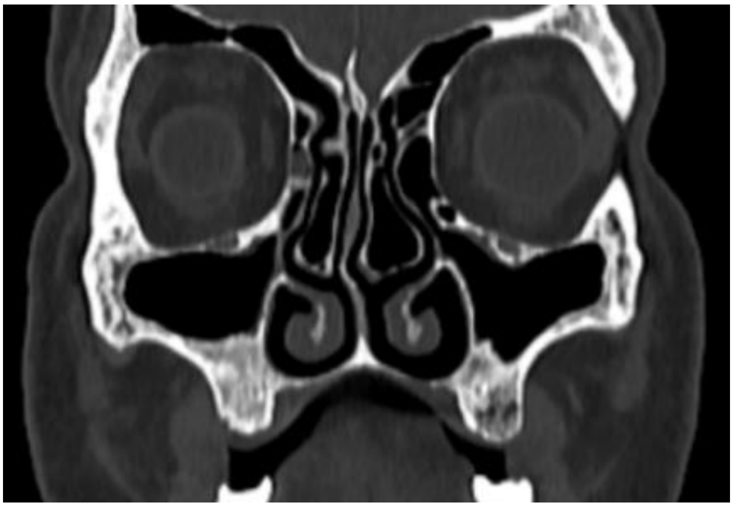


Figure 4: True conchabullosa

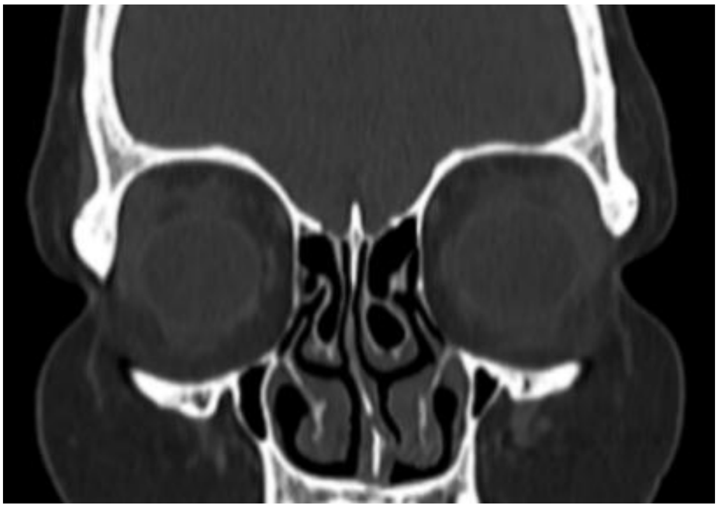


Figure 5 :Bulbous type

3. RESULTS

The study included a review of 157 paranasal CT scans. The majority of participants were aged between 20 and 40 years (56.7%), with a mean age of 32.9 ± 4.3 years. Participants below 20 years constituted 12.1%, while those aged 40–60 years accounted for 31.2%. Males represented a higher proportion of the sample (68.2%, *n* = 107), compared to females (31.8%, *n* = 50) (Table 1).

Table 1-Age distribution among participants

Age	**N**	**%**
<20	19	12.1%
20–40	89	56.7%
40–60	49	31.2%

Fig. 1 summarizes the CT-based diagnoses. Isolated nasal septal deviation (SD) was the most prevalent finding, observed in 29.9% (*n* = 47) of participants. Combined concha bullosa (CB) with septal deviation was noted in 24.8% (*n* = 39), while isolated concha bullosa was present in 10.8% (*n* = 17). In contrast, 34.4% (*n* = 54) of participants had normal CT findings without significant anatomical variations.

A statistically significant difference in laterality was observed between the groups (P = 0.046). Unilateral concha bullosa was more prevalent in the CB + SD group, while bilateral concha bullosa was more common in the isolated CB group (Fig.2).

Fig.1-Distribution based on CT Findings

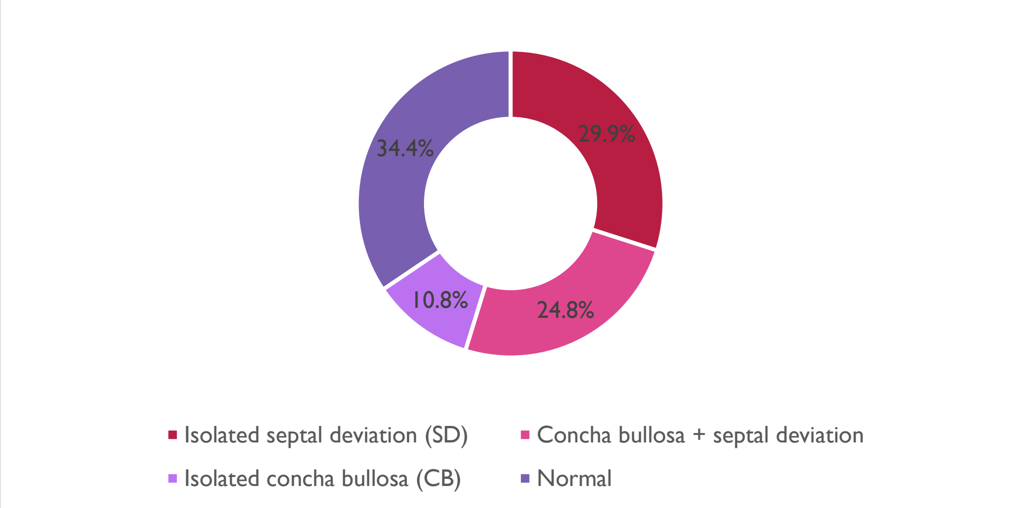


Fig.2-Laterality distribution of Concha bullosa

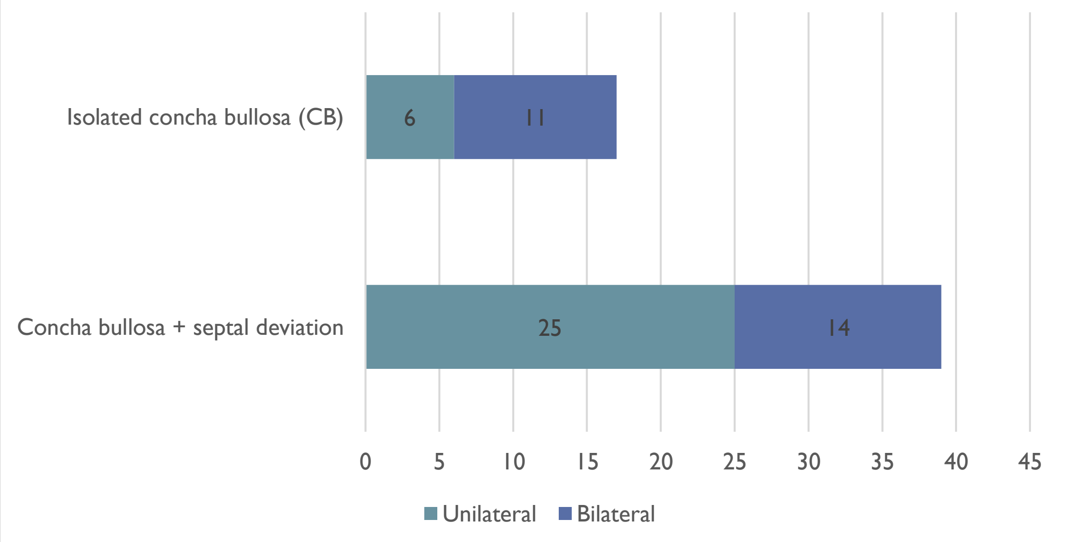


Table 2- Mean deviation of the nasal septum angle

Mean septal deviation	Mean + standard deviation
Isolated SD	14.96+4.95°
Unilateral CB+SD	12.5+4.2°
Bilateral CB+SD	11.6+3.09°

A statistically significant difference was observed in the mean septal deviation angles among the three groups (P = 0.0001), indicating that the degree of septal deviation differed significantly between isolated SD, unilateral CB + SD, and bilateral CB + SD groups.

The mean Concha Bullosa Pneumatization Index (CBPI) was 17.18 ± 1.39 in the CB + SD group, while it was slightly lower in the isolated CB group (16.4 ± 3.93). No statistically significant differences were observed across these subgroups in terms of CBPI (p value=0.648)

Table 3- Mean CBPI of Concha Bullosa subgroups with laterality

Type of CB	Mean CBPI	P value
CB+SD		
Bilateral	17.43±1.153	0.341
Unilateral	16.92±1.63	
CB		
Bilateral	16.94±4.23	0.072
Unilateral	15.89±3.63	

Among patients with CB + SD, the mean CBPI was higher in the bilateral type than the unilateral type; however, this difference was not statistically significant (*P* = 0.341). Similarly, for isolated CB, bilateral cases exhibited a slightly higher mean CBPI compared to unilateral cases, but again without statistical significance (*P* = 0.072).

CB cases were further classified into lamellar, bulbous, and true types. The lamellar type was the most common concha bullosa variant (n = 28), predominantly unilateral (n = 18). Bulbous type showed a near-equal distribution (unilateral: 8, bilateral: 9), while the true type was least common (n = 11), with a slight bilateral predominance. The lamellar type showed the highest deviation angles in both unilateral (14.3 ± 4.1°) and bilateral (13.1 ± 3.3°) groups, while the bulbous and true types demonstrated relatively lower and comparable angles (Fig.3). However, no significant differences in deviation angles were observed between unilateral and bilateral presentations for the lamellar (*P* = 0.480), bulbous (*P* = 0.702), and true types (*P* = 0.905).

As illustrated in Fig. 4, the comparison of mean CBPI values between unilateral and bilateral concha bullosa types revealed no statistically significant differences. For the lamellar type, mean CBPI values were 14.6 ± 2.71 (unilateral) and 15.8 ± 5.48 (bilateral) (*P* = 0.545). For the bulbous type, the means were 17.6 ± 6.23 (unilateral) and 21.2 ± 4.36 (bilateral) (*P* = 0.154). For the true type, the means were 18.6 ± 6.89 (unilateral) and 17.3 ± 5.12 (bilateral) (*P* = 0.638)

Fig.3-Error bar chart depicting septal deviation angles (mean ± standard deviation) among concha bullosa subtypes

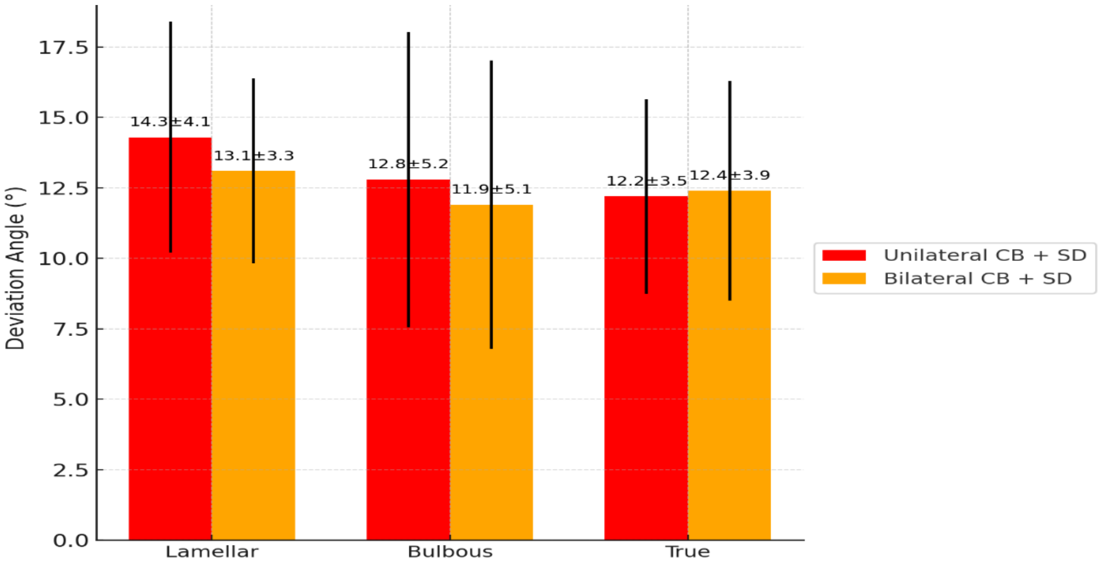
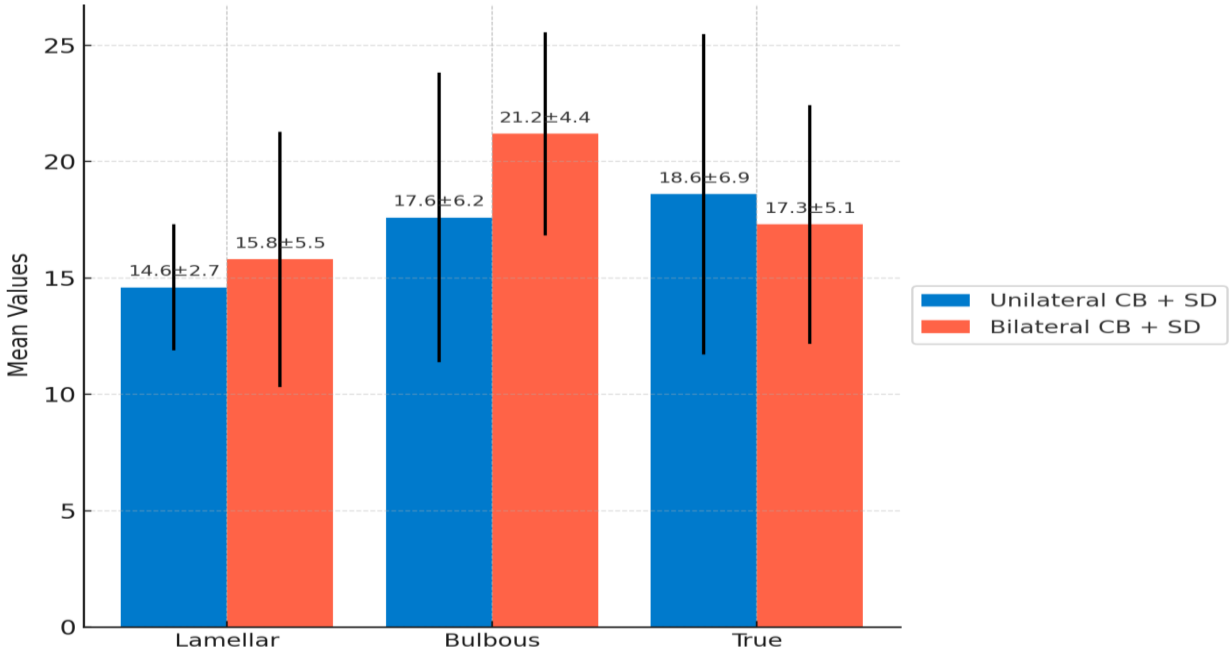


Fig.4-Error bar chart depicting CBPI values (mean ± standard deviation) among concha bullosa subtypes



4. DISCUSSION

The present study found that isolated nasal septal deviation (SD) was the most common anatomical variation (29.9%), followed by combined concha bullosa (CB) with SD (24.8%) and isolated CB (10.8%). This prevalence of CB observed was lower than a study done by Smith et al and Kucybala et al, who reported CB in 67.5% and 42.1% of patients respectively [10][11]. However, our findings closely align with the study by Sazgar et al., who reported a similar CB prevalence[12].The prevalence of SD in the current study is consistent with values reported in the literature, which range from approximately between 19% to 79.9%[10][11][12],as shown in Table 4.

Our study also demonstrated a significant association between unilateral CB and SD, with SD often deviating away from the side of the dominant or unilateral CB, are in line with several previous studies. Stallman et al. and Sazgar et al. both reported a strong association between unilateral or dominant CB and contralateral septal deviation, suggesting a possible compensatory anatomical relationship [7][12]. The current study also supports this, as unilateral CB was more prevalent in the CB + SD group, and the direction of septal deviation was generally away from the side of the dominant CB. Similarly, Uygur et al. noted a higher frequency of contralateral CB relative to SD, along with increased CBPI and deviation angles in such cases (6). Our results also showed higher mean deviation angles in cases with bilateral CB + SD compared to unilateral CB + SD, although differences in CBPI between groups were not statistically significant.

A study done by Mubarki et al concluded that there is no relationship between the degree of pneumatization of concha bullosa and the severity of deviated nasal septum, supporting the findings of the current study [13]. A large retrospective CT study of 1095 patients found a strong association between the presence of concha bullosa and contralateral nasal septal deviation, but importantly, no increased incidence of paranasal sinus disease or direct causative mass effect from concha bullosa on septal deviation was observed [7]. This supports the idea that while concha bullosa and septal deviation often coexist, the degree of pneumatization does not directly influence septal deviation severity.

The predominance of the lamellar type of CB in our sample, particularly among unilateral cases, is consistent with previous anatomical studies, which have also identified the lamellar variant as the most frequent subtype [7][12]. While our study shows higher deviation angles for the lamellar type, the lack of statistical significance between unilateral and bilateral types is consistent with prior research, which generally finds **no significant association between CB type/laterality and septal deviation severity** [14][15]. Some studies suggest a physical relationship between CB and septal deviation, often with the deviation opposite the CB, but do not find significant differences in deviation angles based on CB type or laterality [16]. The mutual influence is noted, but not quantified as statistically significant in terms of deviation degree.

In conclusion, this study highlights the high prevalence and frequent coexistence of nasal septal deviation and concha bullosa, with unilateral CB significantly associated with contralateral septal deviation. Although CB subtype and laterality influenced deviation angles to some extent, no statistically significant differences were observed. These findings underscore the importance of detailed preoperative CT evaluation of sino-nasal anatomical variations.

Table 4-Comparison of CB and SD Prevalence and Their Association Across Studies

Study	CB Prevalence	SD Prevalence	CB & SD Association
Present Study	**35.6% (total)**	**54.7% (total)**	**Unilateral CB more prevalent in the CB+SD group (P<0.05)**
Smith et al.(10)	**67.50%**	**19.40%**	**19.5% of CB had SD (P=0.9)**
Kucybala et al.(11)	**42.10%**	**79.90%**	**Unilateral/dominant CB with contralateral SD (P<0.00001)**
Sazgar et al.(12)	**35%**	**63%**	**Unilateral/dominant CB with SD (P<0.009)**

Limitations: small sample size and convenience sampling were some limitations of our study

Conclusion: Our study concludes that bilateral concha bullosa is common in isolated CB cases and unilateral CB is most common in CB with S.D cases. Also mean septal deviation is higher in unilateral septal deviation with CB compared to bilateral one.

Conflict of interest: Nil

Funding: No external funding

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