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Concha bullosa, nasal septal deviation and paranasal sinusitis; a computed tomographic evaluation

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Abstract. *Concha bullosa, nasal septal deviation and paranasal sinusitis; a computed tomographic evaluation. Problems/objectives*: Although concha bullosa, nasal septal deviation (NSD) and paranasal sinusitis are apparently three independent entities, some studies suggest that they are interconnected. Computed tomography (CT) is a useful and accurate imaging modality for examining this interconnection. The objective of this study is to use CT imaging to investigate the possible association between concha bullosa, NSD and paranasal sinusitis.

Methodology: We reviewed 206 nasal and paranasal CT images of individuals with sinonasal symptoms/cosmetic issues and investigated the association between the presence of concha bullosa and NSD with paranasal sinusitis.

Results: There was no significant relation between the presence of concha bullosa and paranasal sinusitis. The mean NSD was significantly higher in the cases with frontal, maxillary, ethmoid and sphenoid sinusitis than in unaffected subjects. Similar findings were found in the patients with any involved paranasal sinus and the controls ($6.49 \pm 3.06°$ vs. $3.31 \pm 1.99°$; $p < 0.001$). An NSD $\geq 3.5°$ differentiated between the presence and absence of paranasal sinusitis, with a sensitivity and specificity of 77.8% and 76.5%, respectively. A significant positive correlation was found between NSD and the number of involved sinuses (Pearson's $r = 0.58$, $p < 0.001$). The laterality of sinusitis was not associated with NSD or concha bullosa.

Conclusions: Nasal septal deviation, but possibly not concha bullosa, is associated with paranasal sinusitis and its extent. An NSD $\geq 3.5°$ is a useful predictor of paranasal sinusitis.

Introduction

Coronal computed tomography (CT) scans have led to a dramatic improvement in the imaging of the nasal cavity and paranasal sinuses. With this technique, it is easy to detect even subtle variations and anomalies of bony structures and mucosal pathologies.[1]

Nasal septal deviation (NSD) and concha bullosa – partial or total pneumatisation of the middle concha[2] – are very common anatomic variations with a reported prevalence of 1.8-57.6% and 13.2-72.2% respectively.[2,3] Both of these anatomic variations can be accurately examined in CT images.[1]

It has long been thought that both NSD and concha bullosa are linked to the pathogenesis, progression and severity of rhinosinusitis.[4,5] This relationship has been confirmed even in a very recent study and, accordingly, the scrutiny of CT results in subjects with persistent symptoms and recurrent paranasal sinusitis has been recommended.[6]

However, some investigators do not support a causative role for NSD[7-9] or concha bullosa[2,10-12] in the pathogenesis of sinusitis.

This debate, and the importance of clarifying the association between possible contributing factors (such as NSD) and paranasal sinusitis to improve our understanding of the pathophysiology of sinusitis and the consequences for sinusitis management,[13] mean that more detailed investigations are needed to define the possible association between concha bullosa, NSD and paranasal sinusitis.[2]

One of major parameters in this regard, which has been widely neglected by previous studies, is the potential role of sinus disease location.[10]

The main objective of the present study was therefore to investigate a possible association between NSD and frontal, maxillary, ethmoid and sphenoid sinusitis at the individual level. Other minor objectives were to examine the role of sinusitis laterality, the presence of concha bullosa, and the number of simultaneously involved paranasal sinuses in the association between NSD and sinusitis. A final aim was to suggest an optimal cut-off point for NSD to distinguish between cases with and without paranasal sinusitis.

Materials and methods

Between January 2012 and January 2013, we examined the CT scans of nasal and paranasal sinuses in 219 consecutive individuals who were referred to the department of radiology in the Imam Reza Teaching Centre for either complaints attributable to the sinonasal region such as nasal congestion/obstruction, nasal discharge, epistaxis, headache, facial pain, olfactory problems, etc. or for cosmetic concerns.

Of these cases, 13 studies were excluded because either a tumour (n=2) or prior sinonasal surgery (n=3) had destroyed the anatomic structures, or because sinonasal polyps (n=5), sinusitis due to specific causes such as fungal infection, odontogenic problems, immunodeficiency, mucociliary disorders (n=2) or nasal septal perforation (n=1) were documented.

The ethics committee of the Tabriz University of Medical Sciences approved this study and signed informed consent was obtained from the participants.

Computed tomography was performed on a 64-slice spiral scanner (SOMATOM Sensation 64, Siemens AG, Forchheim, Germany) to obtain 2.5-5.0mm axial and coronal images of the sinonasal region.

RadWorks 5.1 Diagnostic Software (Applicare Medical Imaging BU) was used and the degree of nasal septal deviation was quantified on the coronal images by measuring the angle between a straight line drawn from the crista galli to the anterior nasal spine and another straight line drawn from the crista galli downward as a tangent to the most prominent point of the nasal septal curvature (Figure 1).

All the CT images were examined for the degree of NSD, presence of concha bullosa, and probable changes consistent with paranasal sinusitis.

Nasal septal deviation was defined as any bending of the nasal septal contour as evaluated on coronal CT studies.[5] The direction of deviation was described by the convexity of the nasal septal curvature.[12,14] In cases with an S-shaped deflection, the larger angle to the left or right was included in the data.[15]

Pneumatisation of the mucosal tip of the middle turbinate was labelled concha bullosa. In the cases with bilateral concha, the larger one was designated as the dominant concha.[5,12]

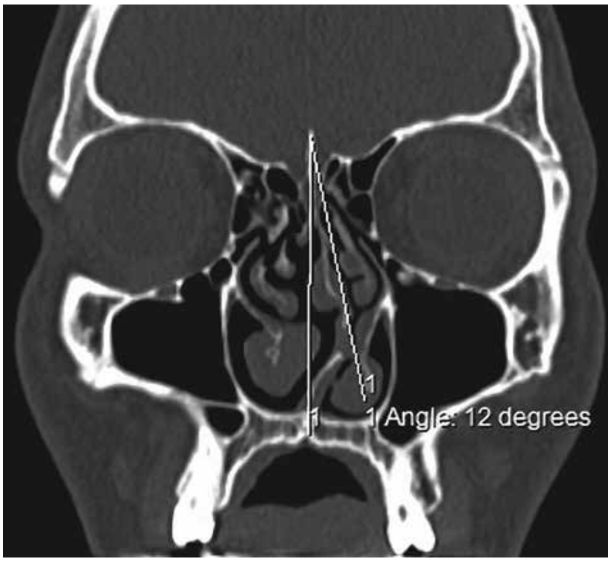

Figure 1
Coronal computed tomographic scan explaining the method used for measuring angle of nasal septal deviation.

The paranasal sinuses (frontal, ethmoid, maxillary, sphenoid) on both sides were examined individually. Any evidence of mucosal changes (minimal mucosal thickening to total sinus opacification) detected on CT, along with relevant clinical findings, was considered to indicate abnormality.[2]

Three skilled radiologists reviewed the CT scans independently and any differences in opinions were resolved by consensus.

Statistical analysis

The data were analysed with SPSS for Windows ver.16.0 (SPSS Inc., Il, USA). Using the results of the Shapiro-Wilk W test and the quantile-quantile plot (Q-Q plot), all quantitative data were distributed normally. Statistical methods included the Chi square (χ^2) test, the independent-samples t test, a two-way analysis of variance (one-way ANOVA), and an ordinal regression model. Receiver operator characteristic (ROC) curves were plotted to determine optimal cut-off points. Correlations were investigated using Pearson's r. P-values ≥ 0.05 were considered statistically significant.

Results

We reviewed the nasal and paranasal CT images of 206 individuals: 124 males (60.2%) and 82 females (39.8%) with a mean age of 34.62±13.74 (range: 18-76) years.

Concha bullosa was present in 72 cases (35%): 38 unilateral (52.8%) and 34 bilateral (7.2%). Single concha bullosa, or larger concha bullosa in bilateral cases were on the right side in 45 cases (62.5%) and on the left side in 27 cases (37.5%).

Paranasal sinusitis was diagnosed in 108 studies (52.4%): frontal sinusitis in 22 patients (10.7%), maxillary sinusitis in 98 patients (47.6%), ethmoid sinusitis in 60 patients (29.1%), and sphenoid sinusitis in 25 patients (12.1%).

In 54 images (5%) only one paranasal sinus was involved.

There were two, three and four concomitantly involved paranasal sinuses in 23 (21.3%), 17 (15.7%), and 14 (13%) images respectively.

The mean NSD was 4.98±3.05° (range: 0-15). The nasal septum deviated to the right in 52 cases (48.6%) and to the left in 55 cases (51.4%).

Nasal septal deviation and concha bullosa

The mean NSD did not differ significantly between subjects with (4.92±2.94°) and without (5.01±3.12°) concha bullosa (independent samples t test p=0.84). Nor was there any significant difference between subjects with unilateral concha bullosa (5.41±2.86°), contralateral concha bullosa (4.75±2.94°), or no concha bullosa (one-way ANOVA p=0.61).

Patients with paranasal sinusitis and subjects with normal paranasal sinuses

Table 1 shows a comparison of the study variables in subjects with and without paranasal sinusitis.

Patients with frontal sinusitis and subjects with normal paranasal sinuses

There was no significant difference between the two groups in terms of age (independent-samples t test p=0.39) and the presence of concha bullosa (χ^2 test p=0.08). More patients were male than in the control group (χ^2 test p=0.04). The mean NSD was significantly higher in the patient group (independent-samples t test p<0.001), even after adjusting for gender (multivariate analysis p<0.001).

Patients with maxillary sinusitis and subjects with normal paranasal sinuses

The two groups were comparable in terms of age (independent-samples t test, p=0.46), gender (χ^2 test, p=0.08) and the presence of concha bullosa (χ^2 test p=0.29). The mean NSD was significantly higher in the patient than in the control group (independent-samples t test p<0.001).

Patients with ethmoid sinusitis and subjects with normal paranasal sinuses

The two groups were matched in terms of age (independent-samples t test p=0.18), gender (χ^2 test p=0.18) and the presence of concha bullosa (χ^2 test p=0.10). The mean NSD was significantly higher in the patient than in the control group (independent-samples t test p<0.001).

Table 1

Studied variables in patients with paranasal sinusitis and the controls

Variable	Frontal sinusitis (n=22)	Maxillary sinusitis (n=98)	Ethmoid sinusitis (n=60)	Sphenoid sinusitis (n=25)	Any sinusitis (n=108)	Control (n=98)
Age (year)	36.70±15.06	35.31±13.89	37.04±14.88	39.77±15.62	35.34±14.09	33.80±13.33
Gender (male)	17 (77.3)*	65 (66.3)	39 (65)	18 (72)	71 (65.7)	53 (54.1)
Concha bullosa	18 (81.8)	30 (30.6)	15 (25)	5 (20)	35 (32.4)	37 (37.8)
NSD (°)	7.91±3.50**	6.47±3.07**	7.17±3.12**	7.60±3.06**	6.49±3.06**	3.31±1.99

Data are presented as mean ± standard deviation and frequency (%).
NSD: nasal septal deviation
* p=0.04, ** p<0.001.

Patients with sphenoid sinusitis and subjects with normal paranasal sinuses

No significant difference was found between the two groups in terms of age (independent-samples t test p=0.07), gender (χ^2 test p=0.11), and the presence of concha bullosa (χ^2 test p=0.09). The mean NSD was significantly higher in the patient than in the control group (independent-samples t test p<0.001).

Patients with any paranasal sinusitis and subjects with normal paranasal sinuses

There was no significant difference between the two groups with regard to age (independent-samples t test p=0.46), gender (χ^2 test p=0.09), and the presence of concha bullosa (χ^2 test p=0.42). The mean NSD was significantly higher in the patients than in the controls (independent-samples t test p<0.001).

Nasal septal deviation and the laterality of paranasal sinusitis

There was no significant difference in mean NSD between the patients with paranasal sinusitis on the same side (n=48, 6.21±2.28°) or on the opposite side (n=60, 6.52±2.21°) from the nasal septal deviation (independent-samples t test p=0.41).

Cut-off point of NSD angle

Table 2 provides a summary of the area under the curve (AUC) values, as well as the optimal cut-off points for nasal septal deviation, with the related accuracy in predicting paranasal sinusitis. Figure 2 shows the associated ROC curves.

Nasal septal deviation and the number of the simultaneously involved paranasal sinuses

Figure 3 shows the mean NSD values stratified by the number of the simultaneously involved paranasal sinuses. Based on the result of one-way ANOVA, a significant difference was present (p<0.001). Paired comparisons between the groups showed significantly higher mean NSD in the cases with more concomitant paranasal sinusitis (Tukey *post hoc* analysis p<0.001 for all comparisons). A significant positive correlation was also present between the NSD value and the rate of paranasal sinusitis in each patient (Pearson's r=0.58, p<0.001).

Discussion

Computed tomography is an accurate way of evaluating the nasal cavity and paranasal sinuses. It is possible to conduct a precise investigation for concha bullosa, nasal septal deviation and paranasal sinusitis at the same time using CT scan images.[1]

In this study, no significant association was found using CT investigation between the presence of concha bullosa and either NSD or paranasal sinusitis.

The available data are controversial in this field. While some investigators have suggested that NSD may be an indirect consequence of concha bullosa,[16] others have found no increased incidence of septal deviation or paranasal sinus disease in patients with concha bullosa.[12,17]

In addition, and in conformity with our results, no significant correlation was found between deviation side (i.e. laterality) and the occurrence of concha bullosa.[18]

Table 2

Optimal cut-off values for the nasal septal deviation as a predictor of paranasal sinusitis

Paranasal sinusitis	Area under the curve*	Optimal cut-off point (°)	Sensitivity (%)	Specificity (%)
Frontal	0.89	4.5	90.9	81.8
Maxillary	0.82	3.5	87.6	86.5
Ethmoid	0.86	4.5	81.7	81.6
Sphenoid	0.88	4.5	80	81.6
Any	0.82	3.5	77.8	76.5

* p<0.001.

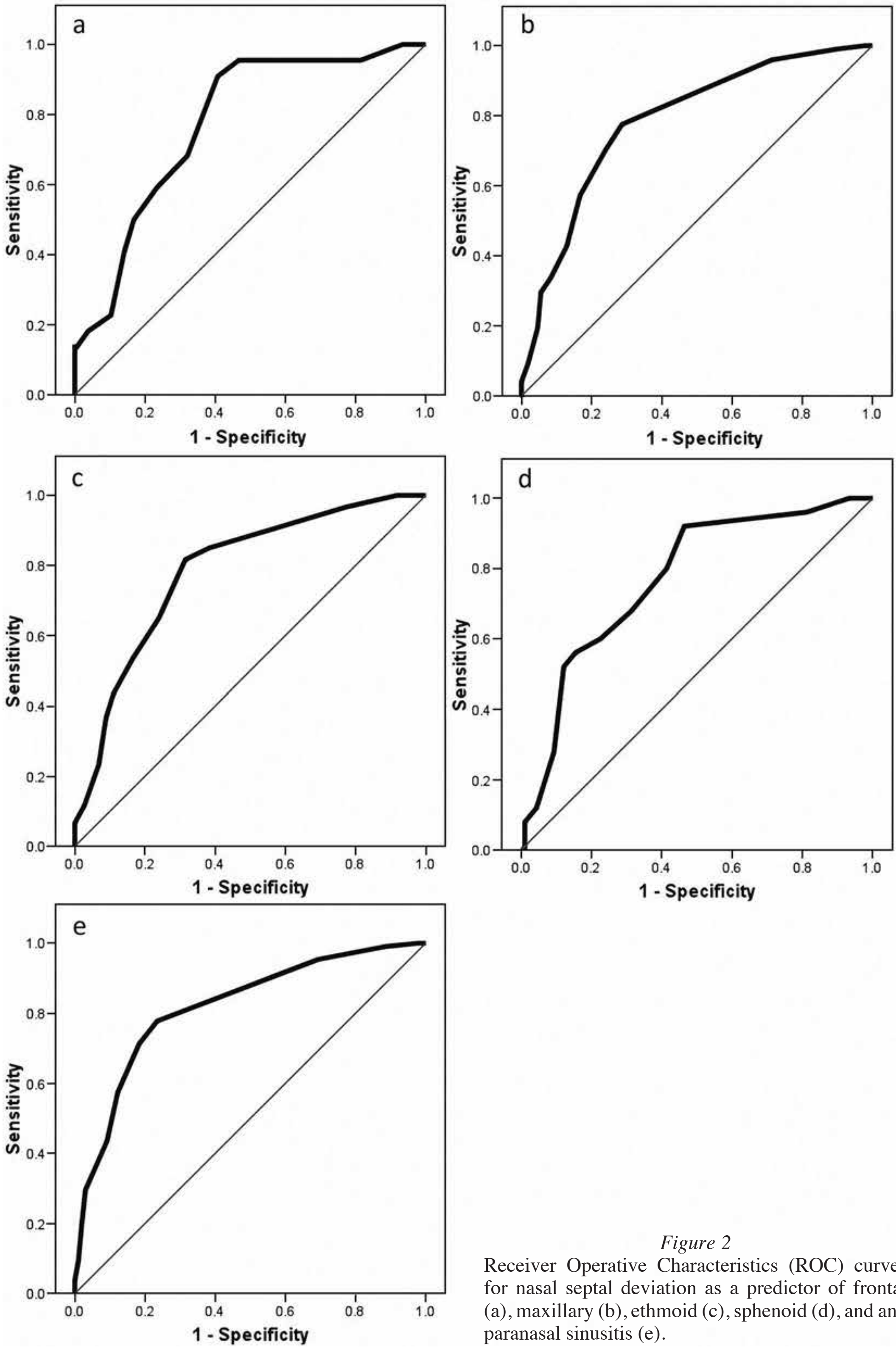

Figure 2
Receiver Operative Characteristics (ROC) curves for nasal septal deviation as a predictor of frontal (a), maxillary (b), ethmoid (c), sphenoid (d), and any paranasal sinusitis (e).

Normal nasal physiology may become altered by the presence of NSD and/or concha bullosa. Either condition can push the concha laterally, narrow the middle meatus, induce nasal obstruction and put the adjacent structures under pressure. These changes in normal structures disturb drainage pathways and mucociliary function. As a result, the nasal blockade is augmented and the risk of infection increases.[2]

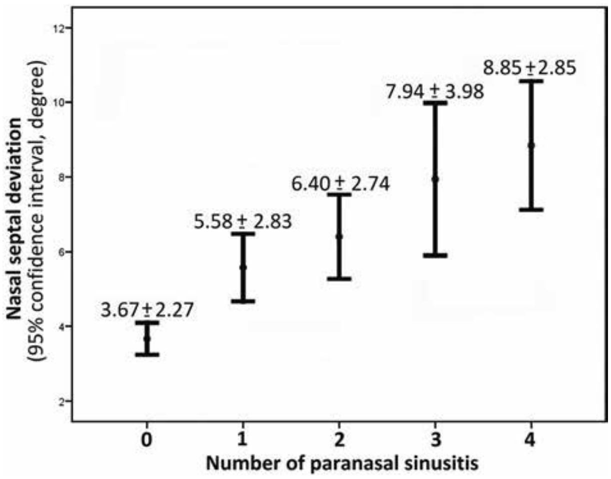

Figure 3
Mean nasal septal deviation stratified by the number of involved paranasal sinuses.
Data are presented as mean ± standard deviation.

Recent findings, however, suggest that concha bullosa cannot cause sinusitis solely by inducing mucosal changes and that obstruction may possibly be more important in the pathogenesis of sinusitis. This obstruction, on the other hand, is only expected in large concha bullosa,[11] which is usually a feature of bullous and extensive, rather than lamellar, types.[19] It has been suggested that the presence of an air column between a deviated nasal septum and concha bullosa excludes the aetiological role of concha bullosa in NSD.[5]

In the present study, we defined any degree of pneumatisation, regardless of size and shape, as consistent with concha bullosa.[17] This may explain the insignificant role played by concha bullosa in the development of NSD or sinusitis. In addition, those reports that have substantiated the validity of a relationship between concha bullosa and sinusitis may have typically included a majority of patients with pre-existing chronic sinusitis.[17]

Some investigators have now examined the impact of NSD on paranasal sinusitis with diverse methodologies and contradictory data have been reported. On the basis of the available data, no definite role can be established or refuted for the nasal septum, either in the pathogenesis of paranasal sinusitis or as a contributing factor.[13]

For instance, while some studies have shown that the NSD angle directly correlates with the incidence and severity of paranasal sinusitis,[15,20] others have reported similar prevalence rates for NSD in patients with radiological rhinosinusitis and their normal counterparts.[7-9]

It should be noted that some of the studies in the second group lacked the power to detect an association between paranasal sinusitis and NSD.[21]

In line with the first group, however, we found a significant association between NSD and paranasal sinusitis.

Various mechanisms may underlie the pathophysiology of sinusitis in association with NSD, such as a deviation-induced mechanical obstruction of the ostiomeatal complex,[13] hampered ciliary activity along with defective mucociliary transport secondary to altered air flow resulting from NSD[4,10] and the negative impact of deviation on antral ventilation.[22]

In addition to the direct effect of NSD on the development of sinusitis, it has been proposed that the craniofacial morphology in patients with a deviated septum may differ from that of patients without deviation or with a less severe deviation; this may represent a possible additional risk factor for sinusitis.[23]

It has been proposed that the location of the sinus disease may contribute to the pathogenesis of sinusitis.[10]

The present study is novel in that it investigated the possible association between NSD and sinusitis in all paranasal sinuses on an individual basis.

In our study, the mean NSD was significantly higher in patients with any type of paranasal sinusitis than in normal subjects.

In addition, an optimal cut-off value for the NSD angle was calculated for distinguishing between cases with and without paranasal sinusitis. Overall, this cut-off value was equal to or greater than 3.5°, and sensitivity and specificity were 77.8% and 76.5% respectively. Reporting a cut-off value for the NSD angle is not unprecedented in the literature. For example, on the basis of the quantitative results from a meta-analysis by Orlandi,[21] a septal deviation angle of 10° has been suggested for distinguishing between positive and negative cases of septal deviation.

To the best of our knowledge, the present study is the first to suggest a cut-off point for distinguishing between cases with and without paranasal sinusitis. Our predictive value (3.5°) is considerably lower than the 10° reported by Orlandi, indicating either a major role for NSD in the pathogenesis of sinusitis or a possible role for ethnic variation. The first hypothesis is supported by a significant positive correlation between the NSD angle and the number of concomitantly involved sinuses in patients with paranasal sinusitis (Pearson's $r=0.58$, $p<0.001$).

It has been previously suggested that laterality may play a role in connecting NSD and sinusitis. For example, Luo *et al*.[24] reported a higher incidence of sinusitis on the narrow side than on the wide side, possibly due to compensatory mechanisms.

By contrast, we found no significant contributing role for laterality in association with sinusitis. This finding is in line with previous reports. Hatipoglu *et al*.[25] found a significant association between NSD and the incidence of sinusitis but laterality proved not to be a significant factor. Kapusuz Gencer *et al*.[14] also reported a significant association between maxillary sinusitis and NSD that was independent of laterality.

Referral bias may be considered a limitation of the present study. This argument would suggest that, since the studied patients were primarily referred for radiographic assessment due to specific symptom(s) attributable to paranasal sinusitis, the statistical inferences of the results apply only to a symptomatic population. Similarly, the possibility of seasonal bias could be raised.

It should be noted that both referral and seasonal bias could lead to an unfavourable outcome only in epidemiological studies that investigate, for example, the incidence of concha bullosa and/or sinusitis. In a case-control setting such as the present study, such limitations are not expected.

In summary, this study showed that the presence of concha bullosa on CT images, independent of shape and size, is not a risk factor for paranasal sinusitis. More importantly, a significant association was found between a deviated nasal septum and paranasal sinusitis. That association is independent of the presence or absence of concha bullosa, age, gender, and laterality. This finding suggests that scrutinising CT results in subjects with persistent symptoms and recurrent paranasal sinusitis is of great importance.[6] In addition, we suggest that an NSD $\geq 3.5°$ is a significant predictor of paranasal sinusitis, a figure that could be important in screening and prevention.

Conclusion

Nasal septal deviation, but possibly not concha bullosa, is associated with paranasal sinusitis and its extent. An NSD $\geq 3.5°$ is a useful predictor of paranasal sinusitis.

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