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Anatomical variations in sinus imaging in sinusitis: a case control study

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Abstract. *Anatomical variations in sinus imaging in sinusitis: a case control study. Objective*: To compare anatomical variations in sinusitis patients and control subjects.
Subjects and methods: We reviewed and compared the computed tomography (CT) scans of 87 sinusitis patients after adequate medical treatment and scans of 103 healthy subjects. All images were scored for sinusitis severity using the Lund-Mackay scoring system. Anatomical variations such as septal deviation, concha bullosa, presence of the Haller's cell, paradoxical middle turbinate, prominent agger nasi cell, and Onodi cell were also recorded.
Results: Of the 190 evaluated CT images, 55.2% of the cases and 47.6% of the controls had septal deviation ($p>0.05$). The prevalence of concha bullosa was 68% in patients and 61% in controls ($p>0.05$).
Conclusion: There were no significant differences in the evaluated anatomical variations between cases and controls in this study. Mucosal inflammation may play a more essential role than anatomical variation in the development of sinusitis.

Introduction

The pathophysiology of chronic sinusitis is not fully understood, although anatomical obstruction of the osteomeatal complex is thought by many to be a major cause of this condition.[1,2] Accordingly, investigators have tried to identify anatomic abnormalities that play a role in this obstruction.[3,4] In particular, the computed tomography (CT) images of patients with sinusitis have been examined for clues to the specific cause(s) of chronic sinusitis in order to reverse it.[5] Advancements in imaging techniques have resulted in higher-resolution scans that reveal anatomical abnormalities in greater detail. One result of this is that careful evaluation of CT scans can protect patients who require surgery from surgical complications due to skull base variations, sphenoid sinus abnormalities, and the status of the lamina papyracea. Thus, otolaryngologists are increasingly interested in understanding anatomical variations of the nose and sinus.[6]

The presence of septal deviation, concha bullosa, Haller cell, and Agger nasi cell are common anatomical variations, but their roles in the pathophysiology of sinusitis is controversial since these variations have a relatively high prevalence in the healthy population.[2-4,7] Moreover, the status of the skull base according to Keros' classification[8] and anatomical variations of the sphenoid sinus are variables that also impact the safety of sinus surgery.

This study compared anatomical variations in sinusitis cases and control subjects to address the question of what roles these variations play in sinusitis.

Subjects and methods

Study subjects

During the study period from January 2009 to September 2010, there were 87 sinusitis cases among the consecutive patients who were referred to the otolaryngology wards of a tertiary referral hospital in Tehran, Iran. This study included adults with clinical and endoscopic findings of sinusitis who had the diagnosis confirmed by imaging and who did not have a history of systemic disease or trauma. Moreover, 103 control subjects were selected during this period that had no history or symptoms of sinusitis and who underwent imaging studies for reasons other than sinusitis. Most of the control subjects had imaging performed to screen for sinusitis before treatment for headache or trauma.

Ethical approval

This study was approved by the Institutional Review Board at the Tehran University of Medical Sciences. Detailed information about the study was presented orally to the participants, and written informed consent was obtained from each. All aspects of the study were conducted in compliance with the principles of the Declaration of Helsinki.

Variables

In addition to collecting demographic data, axial and coronal CT images of the patients and controls were evaluated. All imaging was performed using the same method to obtain high-resolution 2-mm thick images in the axial and coronal planes using the Hitachi W450 CT scan. Contrast media was not used. In coronal imaging, the hard palate was considered the reference and was perpendicular to the axial imaging plane.

All images were reviewed the same way by the same radiologist, and all measurements were performed the same way using the measuring tool in Adobe Photoshop CS (using Bone Window views). Specifically, all films were scanned and converted to JPEG files that could be analyzed using Adobe Photoshop software. The Photoshop measuring tool was used to calculate distances and angles. Furthermore, a 10-mm label was places on each film for better calibration of the measurements. Representative images in Figures 1 and 2 show how we measured the size of the concha bullosa and the septal deviation angle.

Septal deviation was one of the variables evaluated in this study, and the side and the angle of septal deviation (Figure 2) were measured as described above. In addition to measuring the size of the concha bullosa, it was categorized according to the volume it occupied relative to the middle concha: Grade I $< 50\%$, Grade II $\geq 50\%$ but $> 75\%$, and Grade III $\geq 75\%$). Additionally, the presence of the Haller cell, paradoxical middle turbinate, prominent Agger nasi cell, and Onodi cell were noted.

Figure 1
Concha bullosa measurement

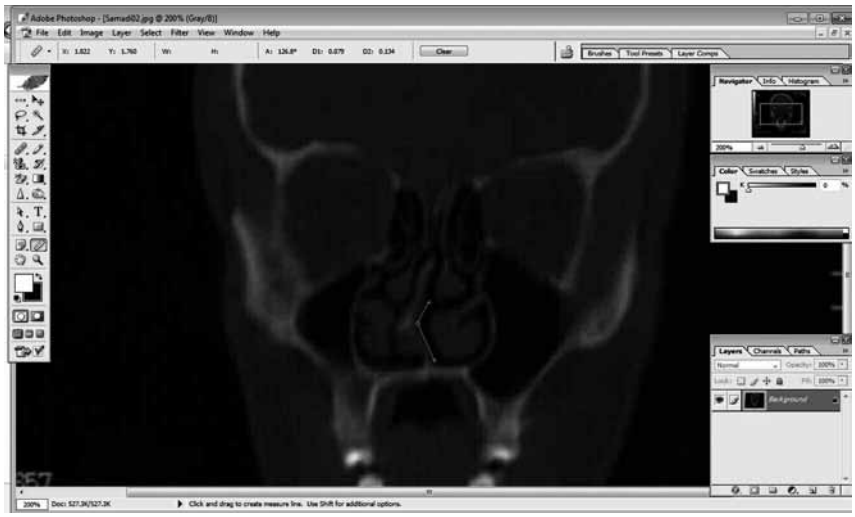

Figure 2
Septal deviation angle measurement

Statistical methods

Data were analyzed using SPSS 15.0 for Windows. The paired t-test was used to compare the the variables in the two groups. The Chi-squared test and the Mann-Whitney U test were also used to analyze data. The values were evaluated using descriptive statistical methods (mean ± SD), and the results were expressed using a significance level of $p < 0.05$.

Table 1
Anatomical variations in sinusitis cases and controls

% Variable	Cases (n = 87)	Controls (n = 103)	p value
Concha bullosa	48 (55.2%)	49 (47.6%)	0.269#
Septal deviation	59 (67.81%)	64 (62%)	0.442#
Paradoxical middle turbinate	33 (37.9%)	53 (51.5%)	0.063#
Pneumatized or prominent uncinate process	11 (12.6%)	10 (11.6%)	0.399#
Haller cell	9 (10.3%)	14 (13.6%)	0.494#
Prominent Agger nasi cell	21 (24.1%)	31 (30.1%)	0.359#
Double middle turbinate	4 (4.6%)	5 (4.9%)	0.93#
Septo bullosa	3 (3.4%)	6 (5.8%)	0.442#
Age, years	33.85 ± 3.79	34.12 ± 5.29	0.34*
Sex, male/female	35/52	38/65	0.067#

*t-test, # Chi-squared test.

Table 2
Frequency and site of septal deviation in sinusitis cases and controls

Group	Site of deviation			Sum
	Lower	Middle	Upper	
Cases (n = 87)	12 (20.3%)	47 (79.7%)	–	59 (100%)
Controls (n = 103)	14 (21.9%)	49 (76.6%)	1 (1.5%)	64 (100%)
Sum	26 (21.1%)	96 (78.1%)	1 (0.8%)	123 (100%)

Results

In this study, the CT images of a total of 190 sinusitis patients and control subjects were evaluated. In order to use parametric statistical methods for data, we used the Kolmogorov-Smirnov test. The results showed that the quantitative variables had a normal distribution. All images were evaluated for anatomical variations that might play a role in chronic sinusitis. The results are summarized in Table 1.

The septal deviation severity was evaluated by calculating the septal deviation angle using Adobe Photoshop software. The average deviation was 102.6 ± 68.9° in the sinusitis group and 91.6 ± 73.4° in the control group (t-test, $p = 0.229$). The deviation site was categorized into three groups as summarized in Table 2, but there were no significant differences between the sinusitis group and the control group (Chi-squared test, $p = 0.442$).

The concha bullosa was categorized according to the pneumatization index, as shown in Figure 3. There were no significant differences between the sinusitis group and the control group in terms of the incidence of concha bullosa in each group (Chi-squared test, $p = 0.29$). Similarly, there were no significant differences in the incidence rates for the presence of the Haller cell ($p = 0.494$), prominent uncinate process ($p = 0.528$), or Onodi cell ($p = 0.66$). The severity and distribution of sinusitis, represented by the Lund-Mackay scores, is summarized in Table 3.

Furthermore, there was no significant relationship for prominent Agger nasi cell with frontal sinusitis ($p = 0.23$) or for Haller cell with maxillary sinusitis ($p = 0.89$). Finally, the relationship of the severity of sinusitis with anatomical variations was evaluated using the Mann-Whitney U-test, and these results are summarized in Table 4.

Discussion

The pathophysiology of chronic sinusitis is of great interest to otolaryngologists, many of whom think that obstruction of the osteomeatal complex is an underlying cause of this condition.[1] As a result, many researchers have looked for anatomical variations that may play a role in the development of sinusitis. Moreover, widespread use of functional endoscopic sinus surgery and possible complications due to anatomical variations of sinus anatomy require every surgeon to be familiar with sinus anatomy. This study was conducted to assess the incidence of the anatomical variations of sinus anatomy in patients with sinusitis and in control subjects. Because the CT scans in this series were performed after sinusitis treatment, the images were not obscured by physiological conditions related to acute infection, allergies, or other pathologies.[1] As a result, our findings reflect clear anatomical findings in both sinusitis patients and control subjects.

We found no significant differences in the incidence of anatomical variations in the cases and

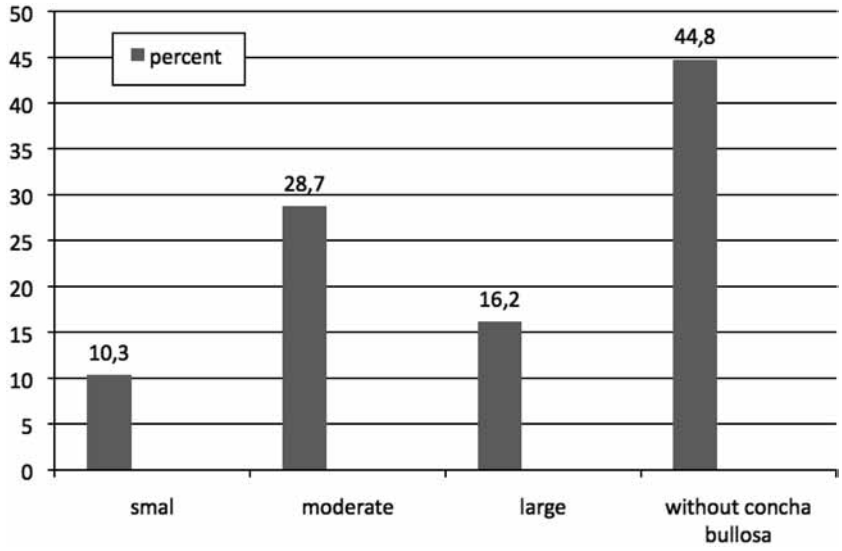

Figure 3
Categorization of concha bullosa in sinusitis cases and controls

Table 3
Sinusitis patient Lund-Mackay scores

Finding	**Right**			**Left**		
Severity Site	**0**	**1**	**2**	**0**	**1**	**2**
OMC	64 (73.6%)	0	23 (26.4%)	59 (67.8%)	0	28 (32.2%)
Maxillary sinus	32 (37.9%)	41 (47.1%)	13 (14.9%)	27 (31%)	41 (47.1%)	19 (21.8%)
Anterior ethmoid	57 (65.5%)	16 (18.4%)	14 (16.1%)	56 (64.4%)	17 (19.5%)	14 (16.1%)
Posterior ethmoid	68 (78.2%)	10 (11.5%)	9 (10.5%)	67 (77%)	12 (13.8%)	8 (9.2%)
Frontal sinus	72 (83.8%)	9 (10.3%)	6 (6.9%)	69 (79.3%)	8 (9.2%)	10 (11.5%)
Sphenoid sinus	75 (86.2%)	5 (5.7%)	7 (8%)	67 (77%)	12 (13.8%)	8 (9.2%)

controls. Similarly, we found no significant relationship between sinus anatomy and sinusitis. Our findings suggest that other mechanisms proposed to be causal in sinusitis should be considered in treating this condition. The high rate of the anatomical variations in individuals without sinusitis shows that these can be considered normal variations. For example, the 30% incidence of concha bullosa and the 50% incidence of septal deviation[6] is comparable to the prevalence of chronic sinusitis in the community. However, this may be merely by chance, or these may not be the only factors that affect sinusitis pathophysiology. Our results are compatible with the findings of other researchers who reported a negative association between these anatomical variations and sinusitis.[2,4,7,9-12]

Messerklinger emphasized that healthy anatomic variants could interfere with mucociliary drainage of the osteomeatal complex, including concha bullosa, a prominent uncinate process, paradoxical turbinate, large Agger nasi cells, Haller cells, and a deviated nasal septum.[1,5,13-17]

However, the inflammatory theory posits that inflammation plays a more important role than such variations.[18] Among the anatomical variations, septal deviation was a common finding in this series, as nearly 68% of the patients had this problem. Others have proposed that the deviated part of the septum can compromise the osteomeatal complex and subsequently impede mucociliary transport, resulting in sinusitis.[2] However, there is a high incidence of similar variations in healthy individuals that do not result in altered sinus function. Similarly, the site and angle of septal deviation were not associated with sinusitis in this study. Therefore, despite the widespread belief that some of these structural variations are causal in the formation of sinusitis,[3] there were no significant differences between cases and controls in this series.

Anatomical variations of the osteomeatal complex are thought to play a minor role as causal factors in chronic rhinosinusitis because such variations do not interfere with the aeration and drainage of the sinuses. Surgical procedures that restore drainage and aeration of the paranasal cavities can be considered essential for treatment of this condition, and surgeons should regard anatomical variations of the osteomeatal complex as key in sinusitis treatment. Before widespread acceptance of this theory

Table 4
Comparison of the average sinusitis severity according to the presence of anatomical variations

Anatomical variation	Presence	Average ± SD (Lund-Mackay score)	p value
Concha bullosa	None	6.7 ± 2.9	0.22
	Present	5.8 ± 3.1	
Septal deviation	None	6.9 ± 3.1	0.28
	Present	6.2 ± 2.9	
Haller cell	None	4.9 ± 2.6	0.42
	Present	5.6 ± 3.1	
Prominent Agger nasi cell	None	5.1 ± 3.3	0.82
	Present	5.2 ± 2.8	
Paradoxical turbinate	None	5.9 ± 2.6	0.44
	Present	5.1 ± 3.2	
Prominent uncinate	None	4.8 ± 2.9	0.27
	Present	3.5 ± 3.1	
Onodi cell	None	6.2 ± 3.4	0.40
	Present	5.8 ± 3.2	

of sinusitis pathophysiology, it should be reevaluated in larger studies.

Conclusion

We found no significant difference between sinusitis cases and controls regarding the evaluated anatomical variations. These findings support the idea that mucosal inflammation plays a more essential role in sinusitis; however, further prospective studies are needed to investigate this.

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