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ORIGINAL ARTICLE

Study of the Anatomical Variations in the Middle Meatus on Nasal Endoscopy

SS Bist, Saurabh Varshney, Sanjeev Bhagat, Sarita Mishra, Vinish Agrawal, Namita Kabdwal

ABSTRACT

Introduction: The anatomical variations of the lateral wall of nose may create technical difficulties during surgery and increase predisposition for chronic rhinosinusitis (CRS). Various cadaveric and radiological studies have been carried out to identify the variations of critical landmarks in sinonasal anatomy. However, studies analyzing the nasal endoscopic examination of living patients are scarce.

Objective: The aim of the study was to compare the anatomical variations in the middle meatus of patients having CRS with that of normal population.

Materials and methods: This was a prospective clinical study, where 700 subjects (1,400 middle meatus) were subjected to diagnostic nasal endoscopy, over a period of 2 years. A total of 350 subjects each with CRS and normal population were included in the case and control group, respectively. Endoscopic examination of nasal cavity was done to observe the middle meatus configuration.

Results: The anatomical variations in the case group were significantly higher that of control. The most common atypical anatomical presentation in both the case and control group were atypical agger nasi (14 *vs* 7%, p-value = 0.0001), concha bullosa in middle turbinate (12 *vs* 9%, p-value = 0.0809), medially projected uncinate process (10 *vs* 4%, p-value = 0.0001), and sausage shaped ethmoid bulla (18 *vs* 10%, p-value = 0.0001). Interestingly, opening of ethmoid bulla was also observed in both the groups.

Conclusion: The prevalence of anatomic variations is significantly higher in the case group. However, the detection of a single anatomical variant itself does not establish the genesis of pathophysiology of CRS. Familiarity with such anatomy is important to optimize surgical treatment of sinus disease, while avoiding complications.

Keywords: Anatomical variations, Middle meatus, Diagnostic nasal endoscopy.

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INTRODUCTION

Aeration and secretions of paranasal sinuses travel a tortuous path through openings, fissures and grooves located on the lateral wall of the middle meatus for their effective drainage. During the development and pneumatization of the ethmoid, this region is anatomically prone to develop morphological variations of bony structures located there, such as the agger nasi, uncinate process, bulla ethmoidal and middle turbinate, further modifying this space already naturally rugged. Even though many authors have related anatomical variations of the middle meatus as the predisposing factor for development of rhinosinusitis, there is no statistical or epidemiological evidence in the literature justifying this statement, leading to significant controversy. The contribution of anatomical variations in the pathophysiology of rhinosinusitis, as an adjuvant in the maintenance cycle of the inflammatory process, seems to be more accepted theory. Several studies correlating the anatomical variations in the region of the middle meatus (ostiomeatal complex) analyzing cuts of computed tomographic (CT) scans in patients with clinical suspicion of recurrent acute and/or chronic rhinosinusitis (CRS) are found in the literature.[1-7] Most of the previous studies have relied primarily on anatomic studies of cadaveric specimens or skulls, or on radiographic analysis. However, there is a paucity of data documenting variations in the anatomical configuration of components of the lateral nasal wall utilizing endoscopic examination of living patients.[8-10] Detailed nasal endoscopy examination enables the better assessment of anatomical variations of the middle meatus. The close proximity of vital structures like orbit and skull base with lateral wall of nose requires an intimate understanding of the variability in sinonasal anatomy. Familiarity with these anatomical variations increase the safety and effectiveness of functional endoscopic sinus surgery (FESS). Moreover, it can also assist in better understanding of the pathophysiology of sinonasal infectious diseases. The objective of this study was to compare the anatomical variations of the middle meatus of patients with CRS and normal population using the nasal endoscope.

MATERIALS AND METHODS

This prospective clinical study was conducted in the Department of Otorhinolaryngology, Himalayan Institute of Medical Sciences, Swami Ram Nagar, Dehradun, over a period of 2 years. Patients attending the ENT Department with clinical diagnosis of CRS and who had undergone diagnostic nasal endoscopy were included in the 'case group'. The control group was taken from patients who had undergone diagnostic nasal endoscopy for any other reason

except rhinosinusitis problem (for example, DCR, endoscopic pituitary surgery case and pan endoscopy in head and neck malignancy). These patients were also verified for the absence of any symptoms of rhinosinusitis. Patients with nasal polyps, history of facial trauma, maxillofacial abnormalities, previous nasal or paranasal sinus surgery, sinonasal malignancy, active infection and age below 12 years were excluded from the study. Prior approval from the institutional ethics and research committee and written informed consent from the patients was taken. In all the study subjects (350 each in case and control group), the nose was prepared with the placement of cotton soaked in 2% lidocaine solution with vasoconstrictor (adrenaline) diluted 1: 2,00,000 in both nostrils and both middle meatus, for 5 minutes. The nose was evaluated with either 0° or 30° rigid nasal endoscope (length 18 cm; diameter 4 mm or 2.7 mm). The nasal endoscopy in all patients was performed by the two senior authors and anatomical variations were labeled in a consistent fashion based on their appearance. All findings were compiled and assessed statistically. The prevalence of anatomical variations was determined in cases and controls. A possible correlation of prevalence of anatomical variations in middle meatus in CRS patients was determined.

Assessment of Anatomical Variations

The variations in anatomical configuration of middle turbinate, agger nasi, uncinate process and ethmoid bulla were categorized. The anatomical variations of agger nasi was categorized as typical and hypertrophied, morphologically characterized by significant medial projection of agger nasi cell. Middle turbinate was morphologically defined as follows: (1) Typical, (2) concha bullosa, characterized by expansion of the middle turbinate, (3) paradoxical middle turbinate, characterized by concavity directed to the septum, (4) bilobe middle turbinate, characterized by irregularity (depression) in the body of the middle turbinate inferior-posteriorly, (5) L-shaped medial turbinate. The anatomical variations of the uncinate process were defined as follows: (1) Nonprojected uncinate process, characterized by total absence of medial projection of the uncinate process on the lateral nasal wall; (2) angled or medially projected uncinate process, characterized by marked medial projection toward the middle turbinate; (3) perforated uncinate process, characterized by opening the ethmoid infundibulum and the nasal cavity; (4) curved uncinate process, characterized by an anterior curve of the anterior free margin. Anatomical variation of ethmoid bulla was categorized into typical and hypertrophic (ballooned) morphologically characterized by wide expansion of the ethmoid bulla in the middle meatus and toward the ethmoid infundibulum.

RESULTS

Endoscopic examination of nasal cavity was done in 700 patients, i.e. 1,400 middle meatus. A total of 350 patients each were included in the cases and controls group. Table 1 shows the demographic profile of the patients included in the study. The age of the patients ranged from 15 to 86 years in both group. The average patient age was 34 and 47 years in case and control group respectively. Maximum numbers of patients (43.7%) were in the age group of 26 to 40 years in case group while 64.2% patients in controls group were above 40 years age. The overall male:female ratio was 1.5:1. The male:female ratio was 1.13:1 and 2.02:1 in case group and in control group respectively. The gender distribution was not similar in the both the groups. In cases group, 186 (53.1%) were males while they contributed to 234 (66.8%) in control group. The prevalence of typical and anatomical variation of the structures of middle meatus (agger nasi, uncinate process, ethmoid bulla and middle turbinate) observed by the endoscopic examination of the study subjects are shown in Graph 1. There was significant increase in the prevalence of anatomical variation in all the middle meatus structures in the case group. The various anatomical presentations of middle meatus observed in both the groups on nasal endoscopy regardless of the side are shown in Table 2. The distribution of anatomical configuration in the case and control group was assessed for any statistical significance by Chi-square test. The anatomical presentation of the agger nasi was atypical in 14 and 7% subjects in case and control group respectively (Fig. 1). This difference was highly significant statistically. Middle turbinate was typical in 74 and 83% in case and control group, respectively. The most common anatomic variation of middle turbinate was concha bullosa observed in 12 and 9% followed by paradoxical curvature found in 11 and 8% subjects in case and control group, respectively (Figs 2 and 3). However, these variations did not differ significantly in both the groups. The uncinate process was classified as having a typical crescent-shaped appearance in 83 and 93% in case and in control group respectively. Most common anatomical variation of uncinate process was medial rotation found in 10 and 4% subjects in case and

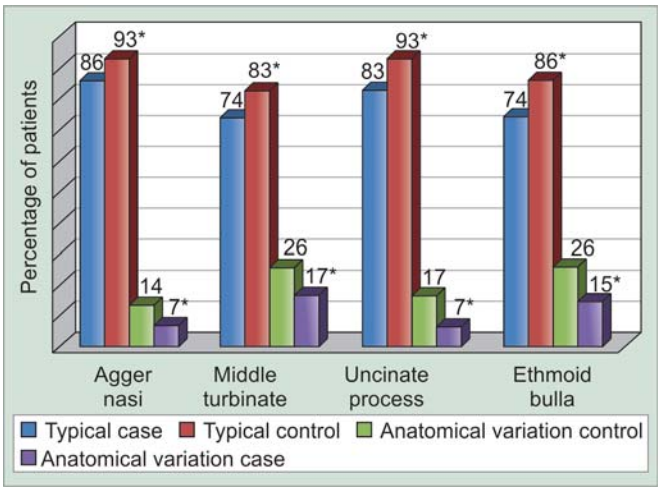
Table 1: Age and sex distribution

Age group	*Nasal endoscopy in cases (n = 350)*	*Nasal endoscopy in controls (n = 350)*
14-25 years	92 (26.2%)	42 (12%)
26-40 years	153 (43.7%)	83 (23.7%)
Above 40 years	105 (30%)	225 (64.2%)
Sex ratio		
Male:female	1.13:1	2.02:1

Table 2: The various anatomical presentations of middle meatus observed on nasal endoscopy in both cases (n = 700) and controls (n = 700)

Anatomical configuration	*Case group (%)*	*Control group (%)*	*p-value*
Agger nasi			
Typical	86	93	0.0001*
Prominent (hypertrophied)	14	7	0.0001*
Middle turbinate			
Typical	74	83	0.0001*
Concha bullosa	12	9	0.0809
Paradoxical	11	8	0.068
Bilobed	2	0	0.0001*
L-shaped	1	0	0.015**
Uncinate process			
Typical	83	93	0.0001*
Angled/middle projection	10	4	0.0001*
Not projected/flattened	4	2	0.0405**
Perforated	2	1	0.1859
Curved	1	0	0.0154**
Ethmoid bullosa			
Typical (balloon)	74	86	0.0001*
Sausage-shaped (hypertrophied)	18	10	0.0001*
Flat	8	4	0.0022*

*Difference between case *vs* control group—highly significant; **Difference between case *vs* control group—significant



Graph 1: Prevalence of typical and anatomical variation in cases and control group (*difference between case *vs* control group—highly significant)

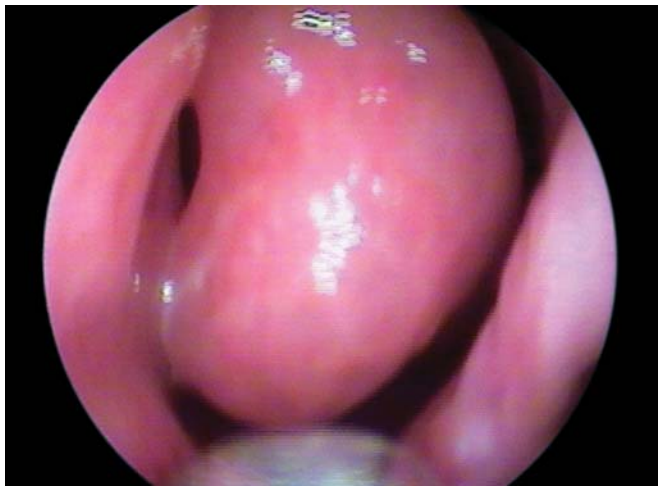


Fig. 2: Concha bullosa with paradoxical middle turbinate (left)

Fig. 1: Prominent agger nasi cell (left)

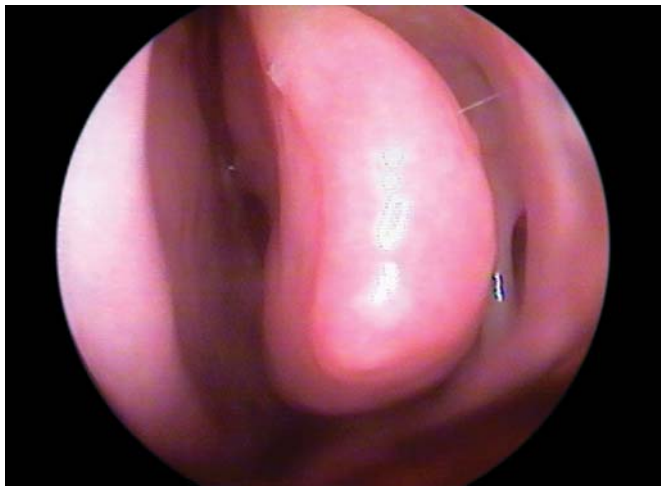


Fig. 3: Paradoxical middle turbinate with perforated uncinate process (left)

control group, respectively and this difference were statistically significant. The ethmoid bulla had a typical appearance in 74 and 86% subjects in case and control group, respectively with a configuration like a circular disk. Most common anatomic variation in ethmoid bulla was sausage-shaped appearance seen in 18 and 10% subjects in case and control group respectively (Fig. 4). Interestingly, opening of ethmoid bulla was also observed in 3 and 1% subjects in case and control group, respectively which was again statistically significant.

Fig. 4: Hypertrophied ethmoid bullosa (left)

DISCUSSION

Endoscopic examination of nasal cavity allows an excellent assessment of the mucous membrane that covers the bony and cartilaginous structures of nasal fossa. The role of anatomical variants in the CRS pathogenesis can be evaluated by comparing prevalence of anatomical variants prevalence in patients having CRS with that of normal population. Many studies have been done on the prevalence of anatomical variants and its relation with CRS, but most of them were done on American and European population. There are very limited endoscopic studies done among Asian population concerning these variations. We observed the prevalence of the possible anatomical structures whose variations could possibly influence in the drainage pathways of anterior group of sinuses. This included the concha bullosa, paradoxical middle turbinate, medial rotation of the uncinate process, pneumatized agger nasi cell and hypertrophied ethmoid bulla. Interestingly, we found that the prevalence of these variations is very common among our population.

Agger Nasi

The reported prevalence of agger nasi cell varies widely among investigator. In various anatomic dissection studies; prevalence of agger nasi cell was variable ranging from 10 to 80%.[11,12] The prevalence of agger nasi in CT scan was also variable. The reported prevalence was as low as 1.07% to a maximum of 100%.[7,13-17] Two endoscopic studies in the literature reported hypertrophy of agger nasi in 17.2 and 6% of the patients.[9,10] In the present study, we found hypertrophy of agger nasi in 14 and 7% of the patients in case and control groups respectively. Usually there is overestimation of agger nasi pneumatization in the endoscopic examination compared to CT scan. It may be due to the angle of vision of the endoscope, subjectivity of the examiner, or infectious process in activity, hindering the observation. A definitive diagnosis of the presence of the disease in the agger nasi can only be made by CT scan. Coronal views clearly demonstrate the anatomic relationship of the agger nasi to the level of the frontal sinus and frontal recess. Studies comparing CT scans and endoscopy findings in the same patients would help us understand such divergence of results. Recognition of this relationship on CT and during endoscopic sinus surgery is essential for the diagnosis and treatment of recurrent chronic frontal sinusitis and its unusual pneumatization causing narrowing of frontal recess can further obstruct mucociliary clearance from the frontal sinus. None of the previous studies have compared the presence of this variation in both patients and controls. In our study this variation was statistical significant in CRS patients suggesting the role of agger nasi in pathogenesis of the CRS.

Concha Bullosa

Conflicting reports of the prevalence of concha bullosa exist in the literature and shows a wide discrepancy. This discrepancy in the prevalence of concha bullosa not only occurs among the CRS patients but also in the normal population. This may be due to genetic difference among different races and perhaps the definition for pneumatization may vary among different investigators. It is difficult to decide when it should be said that the concha bullosa is small and nonsignificant, or *vice versa*. We therefore choose to report hypertrophy of middle turbinate of any degree, as concha bullosa. Middle turbinate pneumatization may be found in patients with sinus disease, as well as in individuals without a history of sinus disease. Separate anatomic studies found conchae bullosa in 25, 20 and 8% of cadaveric specimens.[12,13,18] Various radiological studies reported variable prevalence of concha bullosa in patients ranging from 14 to 73%.[17,19] In one endoscopic study the prevalence of concha bullosa was 51.03% in CRS patients.[9] While another study reported only 15% prevalence of concha bullosa in CRS patients.[10] Similarly, our study revealed

concha bullosa in 12% patients, although we included both pneumatized as well as hypertrophied concha.

One study has reported concha bullosa in 33% of patients with symptoms of sinusitis and 11% in the control group ($p < 0.001$) using coronal CT imaging.[20] Likewise, one more study identified middle turbinate pneumatization in 29% of patients with sinus disease and 15.9% of asymptomatic individuals.[2] While another study found no statistical difference in the prevalence of concha bullosa noted in 35.3% of patients with sinusitis or rhinitis as compared with 13.9% in the control group ($p = 0.042$).[17] Similarly, one more study did not find a higher risk of sinusitis in the presence of concha bullosa. It was therefore postulated that most of the concha bullosa are small and cause no significant narrowing or obstruction.[3] Our study also revealed similar results where concha bullosa was found in 12 and 9% subjects in case and controls, respectively (p-value = 0.0809). We therefore concluded that the presence of this common variation alone is not a risk for development of CRS. The size of the concha bullosa and the association of this variation with other variant which occur simultaneously is another important risk factor to be considered for CRS.

The reported prevalence of paradoxical middle turbinate varies widely. This anatomical variation is easy identified by both methods (CT scan and nasoendoscopy). Anatomic studies found paradoxical middle turbinate in 15% of cadaveric specimens.[12] Using coronal CT imaging, various studies have reported the prevalence of paradoxical middle turbinate between 2 and 26%.[2,3,7,16,17,21] One endoscopic study reported the prevalence of 9.8%.[9] One radiological study using coronal section, reported paradoxical turbinates in 12% of patients with symptoms of sinus disease and 12.2% of asymptomatic individuals.[2] In concurrence, the prevalence of paradoxical middle turbinate was not significantly different in case and control group in our study. The major consequence of these anatomic variations is narrowing of the middle meatus which can lead to obstruction of infundibular drainage. However, the degree of convexity of the middle turbinate is the most important factor to cause the obstruction which will lead to rhinosinusitis. In an endoscopic study bi-lobe middle nasal concha was observed in 0.5 and 2.8%.[8,9] In our study it was observed in 2 and 0% subjects in case and control group respectively and this difference was also statistically significant.

Uncinate Process

In our study most common anatomical variation of uncinate process was medial rotation found in 10 and 4% subjects in case and control group, respectively and this difference was statistically significant (p-value = 0.0001*). Similarly two studies also reported high prevalence of curved uncinate processes between 16 and 21% in CT scans of patients with rhinosinusitis.[16,22] In contrast another study reported an only 3% prevalence of variation of the angled uncinate process.[3] However, the severity of the degree of medialization of the uncinate process and the presence of some other anatomical variation maybe an important associating factor that may increase pathogenic effect leading to CRS rather then the presence of this variation alone. Pneumatization of the uncinate process has been described in previous reports.[17,23,24] Such aeration within the uncinate process may be evident on CT imaging but may be difficult to distinguish from mucosal disease on endoscopic examination alone and therefore was not included in this endoscopic classification system.

Ethmoidal Bulla

The ethmoid bulla arises from pneumatization of the second basal lamella of the ethmoturbinals; therefore its appearance may be quite variable, based on the extent of pneumatization. One radiological study reported 8% of CRS patients with hypertrophied ethmoidal bulla in the CT scan.[21] Conversely, another radiological study reported hypertrophied ethmoidal bulla in 17% patients with orbital tumours but the author admitted that it could have been an overestimation since it is not always easy to assess such anatomical variation by the CT scan.[16] Two endoscopic studies reported the prevalence of hypertrophied ethmoidal bulla in 34 and 14% of CRS patients.[8,10] In contrast in our study hypertrophied (sausage shape configuration) ethmoidal bulla was found in 18 and 10% subjects in case and control group respectively and this difference was statistically significant ($p = 0.0001$*).

The use of endoscopy in this study is novel, as previous reports of anatomical variability have utilized primarily cadaveric specimens or radiographs. Our study serves as a more applicable tool for the endoscopic sinonasal surgeon, because FESS by definition entails an approach to the lateral nasal wall through transnasal endoscopy. Familiarity with the variations in sinonasal anatomy is a prerequisite to safe and effective surgical treatment of sinonasal disease. Although variations in the structures of the lateral nasal wall appear to arise independently and not as part of a syndrome, certain configurations present together may result in a higher prevalence of sinus disease. Endoscopic examination and radiographic study of both asymptomatic individuals and patients with sinus disease would be useful to correlate the prevalence and severity of sinus disease.

CONCLUSION

This study attempts to describe the anatomical variation in middle meatus and compare its prevalence in normal population and CRS patients utilizing the nasal endoscope. Familiarity with such anatomy is important to optimize surgical treatment of sinus disease, while avoiding complications. The prevalence of most of the anatomic variations was found to be significantly higher in the case group. However, the detection of a single anatomical variant itself does not establish the genesis of pathophysiology of CRS.

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ABOUT THE AUTHORS

SS Bist (Corresponding Author)

Associate Professor, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Jolly Grant, Doiwala, Dehradun, Uttarakhand-248140, India, e-mail: sampanbist@yahoo.com

Saurabh Varshney

Professor and Head, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Dehradun Uttarakhand, India

Sanjeev Bhagat

Associate Professor, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Dehradun Uttarakhand, India

Sarita Mishra

Assistant Professor, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Dehradun Uttarakhand, India

Vinish Agrawal

Senior Resident, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Dehradun Uttarakhand, India

Namita Kabdwal

Senior Resident, Department of ENT and Head-Neck Surgery Himalayan Institute of Medical Sciences, HIHT University, Dehradun Uttarakhand, India