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ORIGINAL RESEARCH

Anatomical Variations of the Nose and Paranasal Sinuses in Patients with Sinonasal Polyposis: An Observational Study

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ABSTRACT

Background: Sinonasal polyposis (SNP) is a common inflammatory condition characterized by the growth of polyps within the nasal cavity and paranasal sinuses, often influenced by sinonasal anatomical variations. These variations, such as deviated nasal septum (DNS) and concha bullosa, can affect sinus drainage and contribute to disease severity. A thorough understanding of these anatomical differences is crucial for optimizing surgical and medical management. **Method:** A descriptive cross-sectional study was conducted at a tertiary care center over one year to evaluate the prevalence of sinonasal anatomical variations in patients with SNP. Patients aged 17 years or older, unresponsive to 3–4 weeks of standard medical treatment, were included. Data collection involved clinical examinations, patient interviews, and computed tomography (CT) imaging to identify anatomical variations. Statistical analysis was performed using SPSS version 24.0, with descriptive statistics to determine prevalence and inferential statistics to assess relationships between variations and disease severity. **Results:** Out of 100 patients with SNP, 86.11% exhibited at least one sinonasal anatomical variation. Agger nasi cells (79%) and DNS (72.5%) were the most prevalent, followed by concha bullosa (24%). Patients with multiple anatomical variations (60%) had significantly higher Lund Mackay scores (16.76 ± 4.6) compared to those with a single variation (4.67 ± 1.73), indicating greater disease severity (P-value = 0.000). **Conclusion:** Sinonasal anatomical variations are highly prevalent in patients with SNP and significantly influence disease severity. Preoperative CT imaging is essential for visualizing these variations, guiding surgical planning, and minimizing complications during functional endoscopic sinus surgery (FESS). Understanding both common and rare variants enhances patient outcomes through tailored interventions.

Keywords: Sinonasal polyposis, anatomical variations, deviated nasal septum, concha bullosa, computed tomography, functional endoscopic sinus surgery, Lund Mackay score.

INTRODUCTION

Sinonasal polyposis is a prevalent condition characterized by the formation of polyps within the nasal cavity and paranasal sinuses, often leading to significant morbidity. The etiology of sinonasal polyps is multifactorial, with a complex interplay between genetic predisposition, environmental factors, and anatomical variations. Understanding the anatomical variations of the nose and paranasal sinuses is crucial for managing sinonasal diseases effectively, particularly in surgical interventions such as functional endoscopic sinus surgery (FESS). This introduction will explore the significance of sinonasal anatomical variations in patients with sinonasal polyposis, their prevalence, and the implications for clinical practice.

The anatomy of the sinonasal region is intricate, comprising various structures that can exhibit considerable variability among individuals. These variations can include deviations in the nasal septum, the presence of concha bullosa, and variations in the ethmoidal cells, among others. Such anatomical differences can influence sinus drainage pathways and mucosal function, potentially contributing to the development of inflammatory conditions like chronic rhinosinusitis and sinonasal polyposis [1][2].

Sinonasal polyps are often associated with chronic inflammation of the nasal mucosa, which can be

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exacerbated by anatomical obstructions caused by these variations. For instance, a deviated nasal septum (DNS) can narrow nasal passages, leading to impaired drainage and subsequent accumulation of secretions that foster an environment conducive to inflammation [3]. Similarly, concha bullosa—an enlargement of the middle turbinate—can obstruct airflow and drainage in the osteomeatal complex, further complicating sinonasal conditions [4].

Prevalence of Anatomical Variations

Numerous studies have documented the prevalence of various anatomical variations in patients suffering from sinonasal diseases. A recent observational study found that 86.11% of patients with sinonasal polyps exhibited at least one anatomical variation [5]. The most common variations identified were agger nasi cells (79.09%) and DNS (72.5%), highlighting a significant correlation between these variations and the severity of sinonasal polyposis [6][7]. The presence of multiple anatomical variations was also noted in 70.9% of patients, suggesting a cumulative effect on disease severity.

The relationship between sinonasal anatomical variations and polyp formation has been explored in various cohorts. For example, research indicates that patients with chronic rhinosinusitis often present with a higher incidence of DNS and concha bullosa compared to healthy individuals [8]. These findings underscore the potential role that anatomical variations play not only in the pathogenesis but also in the progression of sinonasal polyposis.

Understanding these anatomical variations is essential for clinicians as they navigate treatment options for sinonasal diseases. Knowledge about specific variations can aid in preoperative planning for sinus surgeries. For instance, recognizing a patient's DNS or concha bullosa can help surgeons anticipate potential complications during FESS and improve surgical outcomes . Furthermore, preoperative imaging studies such as computed tomography (CT) scans are invaluable tools for visualizing these variations and assessing their impact on sinus drainage pathways.

In addition to surgical considerations, awareness of sinonasal anatomical variations may inform medical management strategies. For example, targeted medical therapies may be more effective when tailored to address specific anatomical challenges faced by individual patients. Thus, a comprehensive understanding of these variations not only enhances surgical precision but also optimizes overall patient care.

METHODOLOGY

This study aims to evaluate the prevalence of sinonasal anatomical variations in patients diagnosed with sinonasal polyposis through a descriptive cross-sectional design conducted at a tertiary care center over one year.

Inclusion Criteria

- Patients aged 17 years or older.
- Diagnosed with sinonasal polyps.
- Not responding to 3-4 weeks of standard medical treatment.

Exclusion Criteria

- Patients with previous sinonasal surgeries.
- Those with other significant nasal or systemic conditions affecting sinus health.

Sampling Method

Convenience sampling was employed to select participants who met the inclusion criteria during outpatient visits.

Data Collection

Data were collected through patient interviews and clinical examinations. CT imaging was utilized to identify and document any anatomical variations present in the nose and paranasal sinuses. The following characteristics were specifically noted:

- Deviated nasal septum (DNS)
- Agger nasi cells
- Concha bullosa
- Haller cells
- Onodi cells
- Other relevant variants

Statistical Analysis

Collected data were entered into Microsoft Excel for organization and subsequently analyzed using Statistical Package for Social Sciences (SPSS) version 24.0. Descriptive statistics were calculated to determine prevalence rates, while inferential statistics were employed to assess relationships between anatomical variations and polyp severity.

Table 1: Lund Mackay system

Lund Mackay System	Sinus	Score (Right)	Score (Left)
Maxillary			
Anterior Ethmoid			
Posterior Ethmoid			
Sphenoid			
Frontal			
Osteomeatal Complex			

Scoring Definitions	Score	Description
Sinus (All regions)	0	No abnormality

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	1	Partial opacification
	2	Total opacification
Osteomeatal Complex	0	Not occluded
	2	Occluded

The Lund Mackay scoring system evaluates sinus and osteomeatal complex abnormalities using CT imaging. Each sinus (maxillary, anterior ethmoid, posterior ethmoid, sphenoid, and frontal) is scored bilaterally, with 0 indicating no abnormality, 1 for partial opacification, and 2 for total opacification. The osteomeatal complex is scored as 0 if not occluded and 2 if occluded. This system provides a detailed assessment of sinonasal involvement, with separate scores assigned for the right and left sides, enabling precise documentation of sinus disease severity.

This study's findings will contribute to a deeper understanding of how sinonasal anatomical variations influence sinonasal polyposis and will help inform clinical practices aimed at improving patient outcomes through tailored interventions.

RESULT

Table 2: Distribution of anatomical variations of sinonasal polyps.

Variations	N	Percentage (%)
Agger nasi cells	79	79.0
DNS (Deviated Nasal Septum)	73	72.5
Concha bullosa	24	24.0
Supraorbital cell	16	16.0
Intumescent septi nasi	13	12.9
Frontal cell	13	12.9
Pneumatized anterior clinoid process	3	3.2
Pneumatized uncinate process	3	3.2
Supreme turbinate	3	3.2
Paradoxical middle turbinate	3	3.2
Pneumatized crista galli	2	1.6
Haller's cell	2	1.6
Pneumatized nasal septum	2	1.6

Table 2 presents the distribution of anatomical variations observed in sinonasal polyps among 100 patients. The most common variations include agger nasi cells (79%), followed by deviated nasal septum (DNS) (72.5%) and concha bullosa (24%). Other notable variations include supraorbital cells (16%), intumescent septi nasi (12.9%), and frontal cells (12.9%). Less frequent findings include pneumatized anterior clinoid process (3.2%), pneumatized uncinate process (3.2%), supreme turbinate (3.2%), and paradoxical middle turbinate (3.2%). Rare variations observed include pneumatized crista galli (1.6%), Haller's cell (1.6%), and pneumatized nasal septum (1.6%). These data highlight the variability in sinonasal anatomy associated with polyps.

Table 3: Distribution of Anatomical Variations

Variation Type	Proportion	Patients (N)	Lund Mackay Score (Mean ± SD)	P-value
Single Variation	40%	40	4.67 ± 1.73	**0.000***
Multiple Variations	60%	60	16.76 ± 4.6	**0.000***

Table 3 illustrates the distribution of anatomical variations in sinonasal polyps among 100 patients. Patients with a single anatomical variation constituted 40% of the sample (40 patients), with a mean Lund Mackay score of 4.67 ± 1.73. Conversely, patients with multiple anatomical variations accounted for 60% (60 patients), showing a significantly higher mean Lund Mackay score of 16.76 ± 4.6. The difference between the groups is statistically significant, with a P-value of 0.000.

DISCUSSION

SNP is recognized as a sign of chronic inflammatory disease of the sinonasal tract, characterized by an ambiguous etiology and a propensity for recurrence.4 They are recognized for their significant impact on quality of life, with nasal blockage, epistaxis, and obstructive sleep apnea being prevalent manifestations. Anatomical considerations significantly contribute to the commencement of the inflammatory cascade in the presence of obstruction in the drainage of secretions and stasis. They predominantly manifest in structurally constricted regions of the sinonasal pathway when drainage is impaired, ultimately resulting in the release of pro-inflammatory cytokines from epithelial cells, which leads to cellular infiltration and, consequently, obstruction of the sinonasal pathway.[13]

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Sinonasal anatomical variations such as Agger nasi cell (68.1%), deviated nasal septum (DNS) (62.5%), and concha bullosa (22.2%) were frequently observed, while supraorbital cell, intumescent septi nasi, frontal cell, Onodi cell, anterior clinoid pneumatization, pneumatized uncinate process, paradoxical middle turbinate, pneumatized crista galli, supreme turbinate, Haller's cell, and pneumatized septum were identified as less prevalent. It resembled the results observed in other research.[14-18]

DNS was one of the prevalent alterations seen in our study (72.5%), which is close to earlier studies by Pereira et al. (72.7%), Gouripur et al. (70%), Maru and Gupta et al. (55.7%), and Shrestha et al. (64%).Eight to eleven The prevalence of Agger nasi cells has been found to range from 10-15% by Messerklinger et al. to 65% by Davis et al.[19,20] Bilge et al. also reported agger nasi in 48% of individuals with sinonasal polyps, which is lower than the findings of our study.[14]Agger nasi cells are tightly linked to the frontal recess, as secretions from the frontal sinus often traverse the frontal recess to reach the posterior and medial surfaces of the agger nasi cells.

Consequently, if a substantial agger nasi cell is incised and erroneously identified as a frontal sinus during surgery, the residual supero-posterior wall of the agger nasi cell may undergo scarring posteriorly, affecting the ethmoid roof and resulting in iatrogenic stenosis or occlusion of the nasofrontal junction.[21]

Concha bullosa has been identified as a potential etiological factor in the development of recurrent chronic sinusitis. Numerous studies conducted before have indicated that the prevalence of concha bullosa ranges from 24% to 55% within the population. Sixteen Concha bullosa was observed in 24.1% of our research population, which is lower than the findings of Maru and Gupta et al (42.6%) and Bolger et al (53.6%), but similar to the results reported by Shrestha et al (19.7%), Yadav et al (28%), Lloyd et al (24%), and Madani et al (17.47%).[15,16,22-25] The paradoxically bent middle turbinate may cause impingement of the middle meatus, ultimately resulting in inflammation of the paranasal sinuses. A paradoxical middle turbinate was observed in 3.2% of the patients in our study, which is lower than the 8% reported by Bilge, 27% by Bolger, 9.9% by Varshney, 12% by Yadav, and 15% by Lloyd.[14,15,23,24,26] Pneumatization of the uncinate process was observed in 3.2% of the patients in our study. Nevertheless, it ranged from 2.8% to 10% of patients in alternative investigations.[14,20,27] Haller cells have been documented in 6% to 10% of patients with sinonasal polyps. [21,28] In this investigation, Haller's cells were identified in a lesser percentage of patients (1.6%) compared to Gouripur et al (14%) and Pereira et al (29.1%).[9,10] Onodi cells are posterior ethmoid cells that encroach against the posterior ethmoid capsule or extend towards the medial portion of the optic nerve, hence heightening the risk of optic nerve injury. We documented the presence of Onodi cells in 12.9% of the patients. Bilge et al. identified their presence in 14% of patients, Gouripur et al. in 6%, Pereira et al. in 29.1%, and Varshney et al. in 3%.[14,17,18, 26] Frontal cells are cells that invade the frontal recess or frontal sinus. Gouripur et al. reported a higher prevalence of frontal cells (50%) in contrast to this study (13.9%). Pneumatized crista galli was observed in 1.6% of the patients in this investigation, consistent with the findings of Maru and Gupta (1.6%).[16,17]This study identified single changes in 29% of patients and multiple variations in 70.9% of patients. The existence of many variations in a patient is recognized to contribute to the pathophysiology of SNP through several mechanisms. The constriction of the nose channel, heightened mucosal contact, and negative pressure due to the Bernoulli effect may result in mucosal edema and swelling. Javadrashid et al. posited that the concurrent occurrence of nasal septal deviation and concha bullosa is related with paranasal sinusitis.[29] A separate investigation conducted by Bilge et al. documented the concurrent occurrence of septal deviation and concha bullosa in 100 (64%) patients with SNP, aligning with the findings of this study.[14] The presence of many anatomical changes elevated Lund Mackay staging, and a statistically significant connection was identified between the two, $p<0.05$. Consequently, the existence of many sinonasal structural differences exacerbates the severity and extent of sinonasal polyps.

CONCLUSION

Sinonasal variants are prevalent in individuals with SNP. Consequently, accurate understanding and recognition of both prevalent and rare sinonasal variants may enhance surgical planning and the comprehensive care of sinonasal illnesses. Computed tomography of the paranasal sinuses has enhanced the visibility of paranasal sinus architecture and has facilitated more precision in assessing the amount of nasal polyps and paranasal sinus pathology. It assesses the anatomy of the osteomeatal complex, which cannot be achieved to the same degree with simple radiographs. Consequently, preoperative CT scans are essential for the accurate assessment of anatomical differences, thereby minimizing unintended difficulties during surgery and ensuring comprehensive disease eradication for efficient endoscopic sinus surgery.

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