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Olfactory bulb volumetric changes in nasal obstruction due to septal deviation vs chronic rhinosinusitis with polyposis

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Abstract

Background: Many types of sinus illness produce olfactory impairment. The initial relay for sensory information to the central nervous system is the olfactory bulb, which may be malleable and impacted by deprivation. Olfactory dysfunction may be assessed objectively using magnetic resonance imaging. To compare the olfactory bulb capacity in chronic nasal obstruction owing to septal deviation and CRSwNP patients by side, duration, severity, and subjective sensation of smell.

Method: A cross-sectional research of 43 patients at Al-Yarmouk Teaching Hospital was divided into three groups: (A) control, (B) septal deviation, and (C) CRSwNP. All groups were referred for olfactory bulb magnetic resonance imaging. Using T2-weighted 3D sequence, bulb volume, nasal obstruction in the two diseases, subjective scent, and other characteristics were compared across groups.

Results: Patients aged ≥ 40 years, those with polyposis (20.28 mm^3), those with septal deviation (25.82 mm^3), and those with subjective anosmia/hyposmia had significantly lower mean olfactory bulb volume compared to controls (23.47 VS 44.92.0 mm^3, P= 0.001). Both illness groups showed no significant volume difference in blockage duration > 5 years. Significant weak negative relationships were found between obstruction duration, NOSE score, and volume.

Conclusion: Nasal obstruction reduces olfactory bulb capacity and is impacted by severity, length, pathology, and subjective anosmia/hyposmia. Polyposis causes higher volume decrease than septal deviation, which reduces more on the deviation side. After 5 years, olfactory bulb volume decreases approximately equally independent of blockage degree and disease.

Keywords: Olfactory bulb, magnetic resonance imaging, septal deviation, CRSwNP

Introduction

The sense of smell, or olfaction, plays a critical role in human life by enabling the discrimination of thousands of volatile compounds. It informs us about the safety, aesthetics, and communicative aspects of our environment, such as identifying spoiled food, enjoying fragrances like roses, or facilitating mother-infant interactions [1]. Smell also aids in digestion, triggering gastrointestinal secretions and influencing food flavors. Its significance is highlighted in professions relying heavily on olfaction, like chefs or firefighters, where its loss can lead to significant lifestyle and occupational impacts [2]. Moreover, anosmia (loss of smell) can cause psychological disturbances and affect nutrition, particularly in the elderly, and is linked to decreased longevity [3]. The human nose contains two nasal passages, each serving dual functions in respiration and olfaction. These cavities warm and humidify the air we breathe, filter out pathogens and pollutants, and facilitate the sense of smell. The airflow within the nasal cavity undergoes a transition from laminar to turbulent flow, particularly at the nasal valve, the narrowest part of the respiratory tract. This turbulence allows for prolonged contact of air with nasal mucosa, crucial for olfaction [4]. Odorants reach the olfactory epithelium (OE) either passively or via active sniffing. During normal breathing, a small percentage (less than 15%) of inspired air reaches the OE [5]. The OE undergoes continual regeneration, but this capacity may diminish with age or extensive damage, leading to changes in the epithelium's structure [6]. Sinonasal diseases, like chronic rhinosinusitis (CRS), can significantly impair olfaction. Conditions such as CRS with nasal polyposis (CRSwNP), nonallergic rhinitis, and allergic rhinitis vary in their impact on the sense of smell. These diseases can lead to histological changes in the OE and affect the nasal airflow, obstructing the transmission of odorants [7].

In CRSwNP, nasal polyps form due to chronic inflammation, which may arise from various factors. The exact cause remains unclear, but these polyps are characterized by a robust immune response and are often associated with other conditions like asthma [8]. Septal deviation, another common nasal issue, can cause unilateral airway obstruction, either developmentally or due to trauma. Turbinate hypertrophy, whether mucosal or bony, can also contribute to nasal obstruction and affect olfaction [9]. Diagnosis of olfactory dysfunction involves various methods, including patient-reported outcome measures (PROMs), psychophysical testing (like the University of Pennsylvania Smell Identification Test), and objective techniques such as electrophysiology or imaging [10]. Magnetic resonance imaging (MRI) plays a key role in diagnosing olfactory dysfunctions. MRI technology, which relies on the behavior of hydrogen protons in a magnetic field, has advanced significantly. Its effectiveness is dependent on the signal-to-noise ratio, which is improved with higher field strengths. Various MRI sequences, like T1-weighted and T2-weighted, are used to differentiate tissue characteristics, aiding in the detailed study of structures like the olfactory bulb (OB) [11]. The neuronal activity in the OB is influenced by sensory input from the OE and the olfactory cortex. The OB demonstrates plasticity, partly due to continuous neurogenesis in the OE and possibly from neural stem cells in the brain's lateral ventricle. Although the specifics of human OB neurogenesis remain debated, MRI studies confirm its high plasticity and correlation with olfactory function [12]. The aim of study is to assess the olfactory bulb volume in patients with chronic nasal obstruction due to septal deviation versus CRSwNP concerning the side, duration and severity of each pathology and subjective decrease sense of smell, compared to control regarding the age, side and gender distribution.

Methods

Cross sectional comparative study. The study was conducted at Al-Yarmouk Teaching Hospital in the Department of Otolaryngology and the Department of Radiology, between November 2019 and February 2021. After acquiring the ethical considerations and consent with ensuring the confidentiality and the participant comprehension of aim and process and data usage, 43 participants had been included in the study and classified in 3 groups. Control group (A) included 15 control subjects (8 males, 7 females). Disease group (B) included 14 patients (7 males, 7 females) with chronic nasal obstruction due to septal deviation of either side and severity. Disease group (C) included 14 patients (9 males, 5 female) with chronic nasal obstruction due to CRSwNP (bilateral grade 2).

Inclusion Criteria

1. **Age Range:** Participants aged between 18 and 55 years.
2. **Nasal Complaints**: Experience of nasal obstruction lasting for more than three months.
3. **Control Group:** Individuals without any otorhinolaryngological complaints or pathologies.
4. **Septal Deviation:** Patients presenting with septal deviation of any side or severity.
5. **CRSwNP Patients:** Patients exhibiting Chronic Rhino sinusitis with Nasal Polyposis (CRSwNP) extending beyond the middle turbinate bilaterally (grade 2).

Exclusion Criteria

1. **Medical History:** Past instances of head trauma, congenital smell loss, nasal surgery, and any neurological or endocrine diseases.
2. **Specific Conditions**: History of COVID-19 infection, abrupt olfactory loss following an upper respiratory tract infection, or S-shaped bilateral septal deviation.
3. **Smoking History**: Individuals with a history of smoking.
4. **Consent and Follow-up**: Participants who either refused to consent to the study protocols or were lost to follow-up.

Study Groups and Procedures

- **Control Group (Group A):** This group consisted of individuals visiting the radiology department for MRI scans unrelated to nasal or olfactory issues. They underwent general and ENT head, neck, and cranial nerve assessments. Those with no acute or chronic nasal complaints or pathologies, and without any illnesses affecting the olfactory system, were included. They had OB MRI added to their existing MRI requests.
- **Disease Groups (Groups B and C):** These participants were selected from patients visiting the outpatient clinic of otolaryngology. They underwent a comprehensive ENT, head and neck, and cranial nerve assessment, focusing specifically on nasal conditions.
- **Group B:** Included patients with septal deviation. The assessment included examining the side and severity of the septal deviation, both before and after nasal decongestion, and checking for associated turbinate hypertrophy.
- **Group C:** Consisted of patients with CRSwNP. They were endoscopically assessed and staged using a modified version of the Lund *et al*. endoscopic appearance score.

MRI Analysis

For all participants, the volume of the OB was measured using a 3 Tesla MRI machine. The specific sequence employed was T2-weighted, 3D, Turbo Spin Echo (TSE), in both coronal and sagittal sections. This methodology ensured a thorough and specific assessment of the impact of nasal conditions on the OB, providing valuable insights into the relationship between nasal pathologies and the olfactory system. The data analyzed using Statistical Package for Social Sciences (SPSS) version 25. The data presented as mean, standard deviation and ranges. Categorical data presented by frequencies and percentages. Independent t-test (two tailed) was used to compare the olfactory bulb volume accordingly. Pearson's correlation test (r) was used to assess correlations between olfactory bulb volume and other continuous variables accordingly. A level of P – value less than 0.05 was considered significant.

Fig 1: T2 MRI 3-D of the olfactory bulb and paranasal sinuses of a control participant in coronal (A) and sagittal (B) sections: showing the olfactory bub (the hypointense oval area demarcated by arrow) surrounded by the hyperintense cerebrospinal fluid.

Results

Group (B): 14 patients included, 9 had septal deviation to the right and 5 had septal deviation to the left. In 64.3% severity of deviation was > 50% lateralization Group (c): 14 patients had bilateral nasal polyposis (grade 2). All scored >8 /12 (by the pre-operative endoscopic score of 3 parameters with total score of 12), no comparison was done as they were considered similar in severity, details described in table (1).

Table 1: Distribution of disease groups (B&C)

Finding	No. (n= 28)	Percentage (%)
Diagnosis		
Polyposis	14	32.6
Right Septal Deviation	9	20.9
Left Septal Deviation	5	11.6
Severity of septal deviation (%) n= 14		
< 50	5	35.7
> 50	9	64.3

The comparison among study groups by olfactory bulb volume is shown in table (3.6). Mean OB volume was significantly reduced in disease groups compared to control groups (23.47 versus 44.92.0 cubic millimeters (mm^3), P= 0.001). more details described in figure (2).

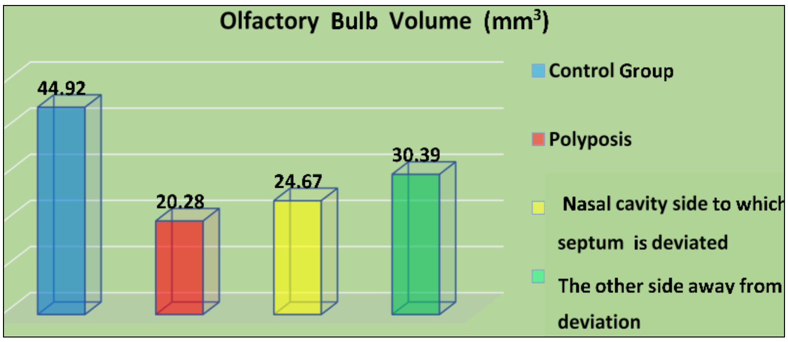

Fig 2: Mean of olfactory bulb volume among study groups

The mean OB volume was significantly reduced in:

1. patients aged ≥ 40 years than that in patients aged < 40 years (P= 0.03)
2. in those with polyposis than that in those with septal deviation (P= 0.005)
3. -in the side of deviation than that in the other sides (P= 0.006
4. in those who complained from symptoms for five years and more than that in those complaining for less than five years (P= 0.001)
5. -in those with septal deviation > 50% than those with < 50% (P= 0.013)
6. in those with subjective anosmia/hyposmia and those without.
7. No significant difference in olfactory bulb volume (P ≥ 0.05) between males and females. Table (2).

Table 2: Comparison in olfactory bulb volume according to certain characteristics of disease groups

Variable	Olfactory bulb volume (mm^3) in disease group Mean ± SD	P - Value
Age (Per years)		
< 40	25.32±7.1	0.03
≥ 40	21.33±6.3	
Gender		
Male	22.55±7.1	0.254
Female	24.7±6.7	
Finding		
Polyposis	20.28±5.7	0.005
Septal deviation	25.82±6.6	
Side of septal deviation		
Deviation side	24.67±5.2	0.006
Other side	30.39±4.9	
Severity of septal deviation (%)		
< 50	30.58±3.5	0.013
> 50	23.88±4.9	
Anosmia		
Yes	21.47±5.4	0.041
No	25.29±6.3	
Duration of obstruction (Year)		
< 5	24.74±5.7	0.001
≥ 5	17.68±4.1	

In patients with duration of obstruction < 5 years, the mean of olfactory bulb volume was significantly lower (P= 0.002) in patients with polyposis than those with septal deviation. In patients with duration ≥ 5 years, no significant statistical difference (P = 0.242) in OB volume between patients with CRSwNP and patients with septal deviation as shown in table (3).

Table 3: Comparison between disease groups in olfactory bulb volume according to duration of symptoms

Duration of symptom	Olfactory bulb volume (mm^3) Mean ± SD	P - Value
< 5 Years		
Polyposis	20.47±4.1	0.002
Septal deviation	27.85±4.7	
≥ 5 Years		
Polyposis	16.28±3.4	0.242
Septal deviation	20.5±4.5	

Statistically significant weak negative correlations were detected between the duration of nasal obstruction and NOSE score with olfactory bulb volume (r= - 0.339, P= 0.02; and r= - 0.327, P= 0.01 respectively). As shown in table (4) and

Table 4: Correlations between the duration of nasal obstruction and NOSE scale score with OB volume

Variable	Olfactory bulb volume (mm^3)	
	r	P - Value
Duration of nasal obstruction (Year)	- 0.339	0.02
NOSE scale score	- 0.327	0.01

The mean OB volume was significantly reduced in those of age ≥ 40 years than that in those of age < 40 years (P= 0.001) and lower in females than that in males (P= 0.001). No significant difference was found in OB volume (P= 0.871) between both sides. Table 5

Table 5: Olfactory bulb volume comparison according certain characteristics of control group

Variable	Olfactory bulb volume (mm^3) in control group Mean ± SD	P - Value
Age (Year)		
< 40	53.26±3.55	0.001
≥ 40	39.35±10.2	
Gender		
Male	51.02±9.08	0.001
Female	37.94±7.7	
Side		
Right	42.26±10.4	0.871
Left	43.02±10.3	

Discussion

In our study of 43 participants aged 18 to 55, divided into three groups (15 in the control group (A), 14 in the septal deviation group (B), and 14 in the polyposis group (C)), we noticed significant trends in olfactory bulb (OB) volumetry and its correlation with olfactory function. Notably, subjective anosmia or hyposmia was prevalent, particularly in the polyposis group (78.6%) and the septal deviation group (50%). Our findings revealed a significantly higher mean OB volume in the control group (44.92 mm³) compared to the disease groups (mean of 23.47 mm³, P = 0.001). This aligns with Sherif M. Askar *et al.*'s study in Egypt [13] and Rombaux *et al.*'s systemic review in Belgium [14], which underscored the impact of nasal obstruction and other pathologies on OB size. In cases of septal deviation, there was a more pronounced OB volume reduction on the deviation side (P = 0.006), correlating with the severity of the deviation. This observation is consistent with findings from studies by Mahmut Ozkiris [15] and Aytug Altundag [16] in Turkey, although there were some variations in the volume changes on the non-deviated side. For CRSwNP patients, the smallest OB volume was noted compared to other groups, a finding supported by studies by Islam R. Herzallah [17] and Reda A. Arabawy [18] in Egypt, which also noted significant changes in OB volume post-surgical treatment. Our study also revealed weak negative correlations between OB volume and both the duration of obstruction and the NOSE score (r = -0.339, P = 0.02; r = -0.327, P = 0.01, respectively), with a significant volume reduction in cases with subjective anosmia/hyposmia. While this contradicted the findings from Arabawy's earlier study [30], it was in agreement with Altundag's [16] and Rombaux's research [14], as well as a German study by D. Buschhüter [19], which found significant correlations between OB volume and various aspects of olfactory function.

Conclusion

In nasal obstructions, olfactory bulb (OB) volume is significantly reduced compared to controls, with the extent of reduction influenced by the obstruction's severity, duration, and underlying pathology. Septal deviation impacts OB volume on both sides, more so on the deviated side. Obstructions due to polyposis result in greater volume reduction than septal deviation. After five years, the OB volume reduction in various nasal obstructions tends to converge. While subjective anosmia/hyposmia shows significant OB volume reduction, using OB volume as an objective measure may more accurately reflect the impact of nasal pathologies on the olfactory system.

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