Section: Anatomy

Original Research Article

MORPHOMETRIC STUDY OF THE HUMAN NASAL CAVITY AND PARANASAL SINUSES: AN ANATOMIC STUDY

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ABSTRACT

Background: The nasal cavity and paranasal sinuses play a crucial role in respiration, filtration, and humidification, influencing various clinical conditions. This study aims to analyze the morphometric dimensions of the human nasal cavity and paranasal sinuses in a sample of 50 individuals, focusing on anatomical variations, symmetry, and gender-based differences. Understanding these measurements is critical for clinical practices such as surgery, diagnostic imaging, and the treatment of sinus disorders.

Materials and Methods: A cross-sectional study was conducted over six months, where computed tomography (CT) scans were used to measure the dimensions of the nasal cavity and paranasal sinuses. Parameters such as length, width, and height of the nasal cavity, as well as the volumes of the frontal, maxillary, ethmoid, and sphenoid sinuses, were assessed. Statistical analysis was performed to compare differences between left and right nasal cavities and between genders.

Results: The average length of the nasal cavity was 5.6 cm (± 0.4), while the width and height were 2.5 cm (± 0.3) and 3.1 cm (± 0.2), respectively. Significant gender differences were observed in frontal and maxillary sinus volumes, with males having larger volumes ($p < 0.05$). Anatomical variations, such as deviated nasal septum (20%) and concha bullosa (16%), were prevalent. No significant asymmetry was found between the left and right nasal cavities.

Conclusion: This study provides essential morphometric data on the nasal cavity and paranasal sinuses, contributing to better clinical management of sinus-related conditions. The findings highlight the importance of considering gender-based differences in anatomical assessments.

Keywords: Nasal cavity, paranasal sinuses, morphometry, anatomy, sinus volume, gender differences, anatomical variations.

INTRODUCTION

The nasal cavity and paranasal sinuses are key anatomical structures involved in respiration, olfaction, and immune defense.[1] They filter, humidify, and warm inhaled air before it reaches the lungs, playing a vital role in respiratory health.[2] Additionally, the paranasal sinuses help reduce the weight of the skull, enhance voice resonance, and protect vital structures during facial trauma.[3] Anatomical variations in these structures, such as deviated nasal septum, concha bullosa, and sinus hypoplasia, can significantly affect nasal airflow and predispose individuals to sinusitis and other disorders.[4]

Understanding the morphometry of the nasal cavity and paranasal sinuses is critical for various clinical applications, including functional endoscopic sinus surgery (FESS), nasal reconstruction, and diagnostic imaging5. Variations in the size and shape of these structures are influenced by factors such as genetics, age, and sex, with gender-based differences often observed in sinus dimensions.[6] Such differences

have practical implications for the diagnosis and treatment of sinus-related conditions.[7]

Previous studies have provided valuable insights into nasal and sinus anatomy, but there is a need for further research to establish normative data on morphometric dimensions across populations. This study aims to provide a detailed morphometric analysis of the human nasal cavity and paranasal sinuses, focusing on anatomical variations, symmetry between the left and right sides, and gender-based differences.

MATERIALS AND METHODS

Study Design and Duration

This was a cross-sectional, descriptive morphometric study conducted over a period of six months, from January 2022 to June 2022, at the Department of Anatomy, Maharajah's Institute of Medical Sciences (MIMS), Nellimarla, Vijayanagaram.

Study Population and Sample Size

The study included 50 participants, aged between 18 to 65 years, who were selected based on predefined inclusion and exclusion criteria. Participants without a history of nasal or sinus surgery, trauma, or chronic sinusitis were included. Individuals with congenital nasal deformities or previous nasal surgeries were excluded. The sample size of 50 was determined based on the availability of CT scans at the institute.

Data Collection

Computed tomography (CT) scans were utilized to obtain detailed images of the nasal cavity and paranasal sinuses. Each participant underwent a high-resolution CT scan, and three-dimensional reconstruction of the nasal cavity and sinuses was performed using specialized imaging software. Measurements were taken from the CT images, including the length, width, and height of the nasal cavity, as well as the volume of the frontal, maxillary, ethmoid, and sphenoid sinuses.

Measurement Parameters

Nasal Cavity: Length, width, and height were measured in both left and right nasal cavities.

Paranasal Sinuses: The volume of the frontal, maxillary, ethmoid, and sphenoid sinuses was calculated.

Symmetry Analysis: Comparative measurements of the left and right nasal cavities were conducted to assess symmetry.

Anatomical Variations: The presence of anatomical variations such as deviated nasal septum, concha bullosa, and paranasal sinus hypoplasia was recorded.

Statistical Analysis

All data were analyzed using statistical software. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were calculated for the morphometric dimensions. A paired t-test was used to assess the symmetry between left and right nasal cavities, while an independent t-test was used to analyze gender-based differences in sinus volumes. A p-value of less than 0.05 was considered statistically significant.

Ethical Approval: Ethical approval for the study was obtained from the Institutional Ethics Committee of Maharajah's Institute of Medical Sciences (MIMS), Nellimarla, Vijayanagaram. Informed consent was collected from all participants prior to the study.

RESULTS

Nasal Cavity Dimensions

The mean dimensions of the nasal cavity were assessed in the study sample (n = 50), and the findings are summarized in Table 1. The average length of the nasal cavity was found to be 5.6 cm (± 0.4 cm), with a minimum of 5.0 cm and a maximum of 6.4 cm. The mean width of the nasal cavity was 2.5 cm (± 0.3 cm), ranging from 2.0 cm to 3.1 cm. The average height was 3.1 cm (± 0.2 cm), with a range from 2.8 cm to 3.5 cm. These findings suggest limited variation in nasal cavity dimensions across the sample population, which is consistent with normal anatomical ranges.

Paranasal Sinus Volumes

The paranasal sinus volumes were measured and are presented in Table 2. The frontal sinuses had an average volume of 6.5 cm^3 (± 0.8 cm^3), ranging from 5.0 cm^3 to 8.0 cm^3. The maxillary sinuses had the largest volume with a mean of 15.4 cm^3 (± 2.1 cm^3), while the ethmoid sinuses showed the smallest average volume of 4.2 cm^3 (± 0.5 cm^3). The sphenoid sinuses had a mean volume of 7.8 cm^3 (± 0.9 cm^3), with a minimum of 6.0 cm^3 and a maximum of 9.2 cm^3. These values highlight the variability in the size of different paranasal sinuses, which can have clinical implications for sinus function and pathology.

Symmetry of Nasal Cavities

Symmetry between the left and right nasal cavities was analyzed for length, width, and height. As shown in Table 3, there were no statistically significant differences between the left and right sides for any of the parameters. The mean lengths were 5.6 cm (± 0.3 cm) for the left nasal cavity and 5.6 cm (± 0.4 cm) for the right nasal cavity ($p = 0.78$). Similarly, the width ($p = 0.91$) and height ($p = 0.55$) showed no significant asymmetry. These results suggest that the nasal cavities are generally symmetrical within the population studied.

Prevalence of Anatomical Variations

Several anatomical variations were observed among the sample population (Table 4). A deviated nasal septum was the most prevalent variation, occurring in 20% of the sample (n = 10). Concha bullosa was present in 16% of the population (n = 8), while 10% (n = 5) exhibited paranasal sinus hypoplasia. Accessory ostia were found in 8% of the cases (n = 4). These anatomical variations could be relevant for

clinicians in diagnosing and managing sinus-related conditions.

Gender-Based Differences in Sinus Volumes

Gender-based differences in sinus volumes were examined, with the results summarized in Table 5. Statistically significant differences were observed in the volumes of the frontal and maxillary sinuses between males and females. Males exhibited a larger mean frontal sinus volume (7.1 cm^3 ± 0.7 cm^3) compared to females (6.0 cm^3 ± 0.8 cm^3), with a p-value of 0.03. Similarly, maxillary sinus volumes were significantly larger in males (16.1 cm^3 ± 1.9 cm^3) compared to females (14.5 cm^3 ± 2.0 cm^3), with a p-value of 0.04. No significant differences were found for the ethmoid and sphenoid sinuses. These findings align with previous studies suggesting that males generally have larger paranasal sinuses than females, which could be important for clinical interventions involving these anatomical structures.

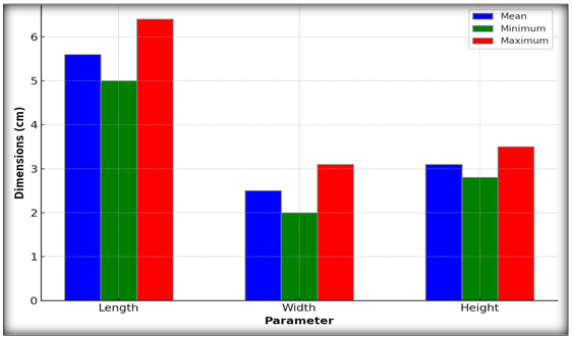

Figure 1: Nasal Cavity Dimensions

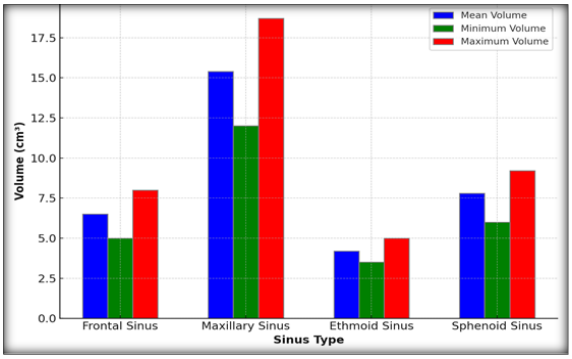

Figure 2: Paranasal Sinuses Volumes

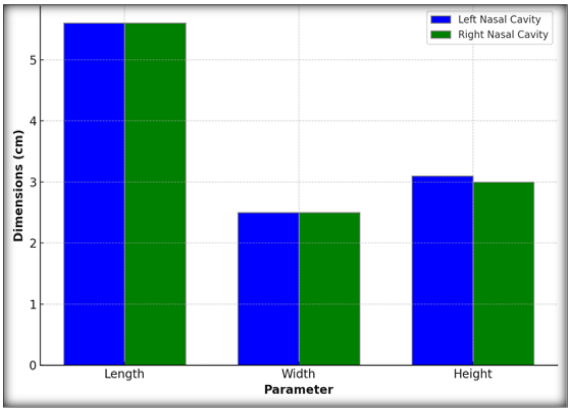

Figure 3: Symmetry Between Left and Right Nasal Cavities

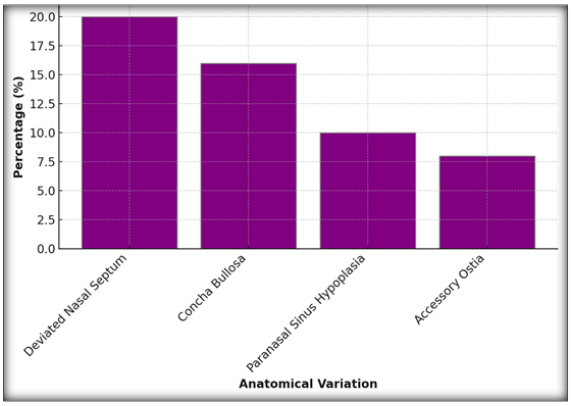

Figure 4: Prevalence of Anatomical Variations

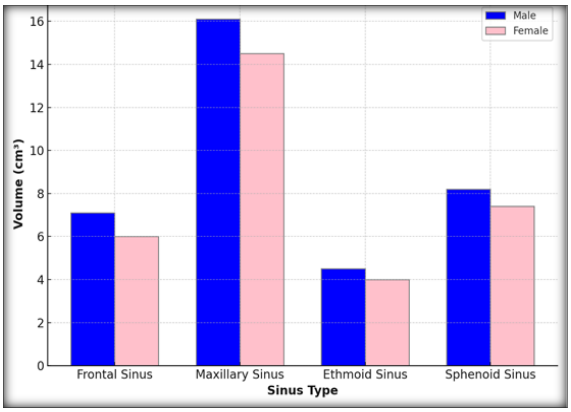

Figure 5: Comparative Sinus Volumes Between Genders

Table 1: Nasal Cavity Dimensions

Parameter	Mean (cm)	Standard Deviation (cm)	Minimum (cm)	Maximum (cm)
Length of Nasal Cavity	5.6	0.4	5.0	6.4
Width of Nasal Cavity	2.5	0.3	2.0	3.1
Height of Nasal Cavity	3.1	0.2	2.8	3.5

Table 2: Paranasal Sinuses Dimensions

Sinus Type	Mean Volume (cm^3)	Standard Deviation (cm^3)	Minimum Volume (cm^3)	Maximum Volume (cm^3)
Frontal Sinus	6.5	0.8	5.0	8.0
Maxillary Sinus	15.4	2.1	12.0	18.7
Ethmoid Sinus	4.2	0.5	3.5	5.0
Sphenoid Sinus	7.8	0.9	6.0	9.2

Table 3: Symmetry Between Left and Right Nasal Cavities

Parameter	Left Nasal Cavity (Mean ± SD)	Right Nasal Cavity (Mean ± SD)	p-value
Length (cm)	5.6 ± 0.3	5.6 ± 0.4	0.78
Width (cm)	2.5 ± 0.3	2.5 ± 0.3	0.91
Height (cm)	3.1 ± 0.2	3.0 ± 0.2	0.55

Table 4: Prevalence of Anatomical Variations

Anatomical Variation	Frequency (n)	Percentage (%)
Deviated Nasal Septum	10	20%
Concha Bullosa	8	16%
Paranasal Sinus Hypoplasia	5	10%
Accessory Ostia	4	8%

Table 5: Comparative Sinus Volumes Between Genders

Sinus Type	Male Volume (Mean ± SD) cm^3	Female Volume (Mean ± SD) cm^3	p-value
Frontal Sinus	7.1 ± 0.7	6.0 ± 0.8	0.03*
Maxillary Sinus	16.1 ± 1.9	14.5 ± 2.0	0.04*
Ethmoid Sinus	4.5 ± 0.4	4.0 ± 0.6	0.12
Sphenoid Sinus	8.2 ± 0.8	7.4 ± 1.0	0.06

Note: Significant difference observed between genders for Frontal and Maxillary sinuses ($p < 0.05$).

DISCUSSION

The present morphometric study provides valuable insights into the anatomical dimensions of the human nasal cavity and paranasal sinuses, emphasizing variations and gender-based differences. These findings are essential for clinical and surgical applications, particularly in functional endoscopic sinus surgery (FESS) and diagnostic imaging, where detailed anatomical knowledge is crucial (Hur et al,[8] 2016).

Nasal Cavity Dimensions

The study revealed that the mean dimensions of the nasal cavity—length, width, and height—fell within the expected anatomical ranges. Notably, the general symmetry between the left and right sides was consistent with prior research, which indicates that symmetry is common in healthy individuals (Papadopoulou et al,[9] 2021). However, even minor individual anatomical variations must be considered during surgical planning to avoid complications.

Paranasal Sinus Volumes

Significant variability was observed in the paranasal sinus volumes, with the maxillary sinus having the largest mean volume. This variability has clinical implications, especially in terms of sinus ventilation and drainage, which are critical for managing conditions like sinusitis (Cardesa et al,[10] 2017). The larger volume of the maxillary sinus compared to the ethmoid and sphenoid sinuses aligns with the findings of Karakas and Kavakli,[11] (2005) and highlights the importance of understanding these differences for effective treatment.

Gender Differences

Statistically significant differences in frontal and maxillary sinus volumes were observed between male and female participants, with males exhibiting larger sinuses. These findings support previous literature that attributes sex-based anatomical differences to variations in skull and facial bone structure between genders (Gruszka et al,[12] 2022). Such anatomical differences are crucial for tailoring surgical approaches and understanding gender-based predisposition to conditions like chronic sinusitis.

Anatomical Variations

A notable proportion of the study population exhibited anatomical variations, with deviated nasal septum (20%) and concha bullosa (16%) being the most common. These variations are clinically significant as they contribute to airflow obstruction, recurrent sinusitis, and difficulties in nasal breathing (Hur et al,[8] 2016). The recognition of these variations is crucial for surgeons, especially when performing rhinoplasty or sinus surgeries, where precise anatomical knowledge is vital to minimizing complications.

Clinical Implications

The data from this study can serve as a reference for normal nasal and sinus dimensions, aiding clinicians in identifying deviations from the norm that may be indicative of pathology. Surgeons, particularly those performing procedures such as FESS, can benefit from the understanding of sinus volume variability and anatomical variations to plan more effective interventions. The gender differences in sinus dimensions should also be considered in surgical and medical treatment protocols.

Limitations and Future Research

One limitation of the study is the relatively small sample size, which may not capture the full range of anatomical variations present in the broader population. Additionally, the study population was limited to individuals attending the Maharajah's Institute of Medical Sciences, which may limit the generalizability of the findings to other populations. Future studies could expand the sample size and include individuals from diverse ethnic and age groups to provide more comprehensive normative data on nasal and sinus anatomy.

CONCLUSION

The present morphometric study provides essential data on the dimensions and variations of the nasal

cavity and paranasal sinuses. The nasal cavities were found to be largely symmetrical, while significant gender differences were observed in sinus volumes, with males having larger frontal and maxillary sinuses ($p < 0.05$). Anatomical variations, such as deviated nasal septum (20%) and concha bullosa (16%), were also prevalent. These findings underscore the necessity of personalized treatment approaches in sinus surgery, considering both anatomical asymmetries and gender differences.

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