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CT Measurement of Maxillary Sinus Volume Among the Population of Rajshahi District in Bangladesh

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Abstract

Background: The volumetric measurement of the maxillary sinuses is essential in assessing the incidence of sinusitis and cancer and measuring the intimate relationship between teeth and maxillary sinuses. There have been reports in multiple studies that there is racial variation concerning age and gender. This study aims to determine whether the sinus volume of males and females differ and its relation to age.

Methods: This descriptive observational study was carried out among 100 respondents between the age of 11- 60 years who were residing in Rajshahi during the study period of one year, i.e., January 2018 to December 2018. The data has been collected from the Department of Radiology and Imaging of Rajshahi Medical College Hospital (RMCH) from the patients who had undergone CT scan examinations. The measurements were directly taken from a computer provided with an electronic caliper. After that, the sinus volume was calculated manually using the following formula (height x width x depth x 0.5). The quality of the data was obtained diligently, and ethical issues were properly maintained in all the steps of this study.

Results: There were 50 males and 50 females, ranging from 11 – 60 years of age, where the mean (± SD) age was 36.7 (± 14.8) years. The mean (± SD) volume of the maxillary sinus in the male group was 17 (± 4.6) cm^3 for the right side and 17.5 (± 4.7) cm^3 for the left side, which was significantly more than the female group, 14.7 (± 3.7) cm^3 for the right side and 15.1 (± 3.7) cm^3 for the left side (p = 0.031). Concerning age, the distribution of maxillary sinus volume showed the highest values between 21-30 years of age, and then it decreased both on the right and left side; this finding was found to be statistically significant (p = 0 .018).

Conclusion: This study provides salient information regarding maxillary sinus volume among the people of the Rajshahi district of Bangladesh. This study's results will help establish a reference dataset regarding anatomical measurements of the maxillary sinus.

Keywords: Maxillary sinus, sinus volume, CT measurement.

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Introduction

The paranasal sinuses are air-filled spaces within the bones of the skull and face. They are usually four paired, Frontal, Maxillary, Ethmoidal, and Sphenoidal. The knowledge regarding human paranasal sinus aeration was initially developed by taking anatomical measurements, injecting different materials into cadavers, or performing plain radiography.[1]

The paranasal sinus (PNS) development pattern can vary according to the individual and age. Sometimes in the same person, it has been seen that both maxillary sinuses may develop differently. The analysis of the diverse

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morphology of the maxillary sinus and classification of the developmental pattern may interest anthropologists and clinicians.[2] In addition, the development of the PNS can be affected by genetic abnormalities, past infections, and the environment.[3]

The maxillary sinuses represent a complex anatomical structure with significant inter and intra-individual variation.[4] The measurement regarding it can be explored easily by computed tomography (CT), which has the advantage of plainly demonstrating the component of the maxillary sinus in comparison to conventional radiographs where inaccuracy occurs due to superimposition of the other paranasal sinuses and the craniofacial skeleton on the upper portion of the maxillary sinus.[5]

A study done by Fernandes[6] revealed that maxillary sinuses are larger in volume in males than in females in Europe. However, in Zululand, Africa, it has been found that the maxillary sinuses are narrower in males than in females. The difference in the volume of the maxillary sinus between the different gender in the two continents explains that the maxillary sinus has a racial role.

The maxillary sinus is the largest among paranasal sinuses. The functional role of the paranasal sinuses has often been disputed, but primary hypotheses have been: to add resonance to the voice; to warm and moisten air during inspiration; to play a role in mucus secretion; olfaction; and to lighten the skull.[7] The function of healthy PNS depends on drainage and ventilation; obstruction in the sinus can lead to various diseases.[8]

Thus, this study was done to find out our community's normal volumetric maxillary volume by computed tomography and if any relation is present with age and gender, which would help both for diagnostic and prognostic purposes of sinus disease.

Materials and Methods

This descriptive observational study was carried out among 100 respondents between the age of 11-60 years who were residing in Rajshahi during the study period of one year, i.e., January 2018 to December 2018.

The data was collected from the Department of Radiology and Imaging of Rajshahi Medical College Hospital (RMCH) from the patients who had undergone CT scan examinations and were willing to participate in the study. Individuals were excluded if they had a history of maxillofacial trauma, paranasal sinus surgery, and if there were signs of facial abnormalities. After the CT scan examination, measurements were taken directly from a computer with an electronic caliper. After that, the sinus volume was calculated manually using the following formula (height x width x depth x 0.5).

The data were collected by a checklist, where the particulars of the patient, history of falls or comorbidities, clinical evaluation, and radiological measurements were recorded. The data were collected by skilled data enumerators and radiological technologists using all necessary precautions.

Before entering into CT scan room, all metallic materials were removed, and a final examination of the subject was done. The subject was then set on a CT scan table in the supine position, without contrast medium or sedation; the head was fixed, and head bags were placed around the head. No movement of the subject was allowed to avoid image artifacts. CT scans of all subjects were reported by radiologists, scoring as normal. This study used a CT scan machine in the Radiology Department of Rajshahi Medical College and Hospital (Philips, Ingenuity core 64 slices, Model 2016, 120kV, scanning at 5mm slice thickness).

The quality of the data was obtained diligently, and ethical issues were properly maintained in all the steps of this study. Furthermore, all data collected were collected by taking consent of the patient or patient's legal guardian and their contact number, which guaranteed that all data were traceable.

Data analysis was done using Statistical Package for the Social Sciences (SPSS) software. As a result, quality was assured in every research step, including protocol development, data collection, data processing, and data entry and analysis.

Results

The volume of the right maxillary sinus

The right maxillary sinus exhibited the highest volume between 21 – 30 years of age and the smallest between 11 – 20 years of age. The difference in the volume of the right maxillary sinus concerning age was statistically significant ($p < 0.05$). In males, the distribution of the volume of the right maxillary sinus was significantly heterogeneous concerning age, with the highest volume being observed in the age group 21 – 30 years and the lowest being in 51 – 60 years ($p < 0.05$). In females, the highest volume was observed in 31-40 years. However, the distribution of the volume of the maxillary sinus concerning age was found to be statistically not significant ($p > 0.05$) (Table 1).

Table I: Distribution of volume of right maxillary sinus according to gender and age (Mean ± SD, cm^3)

Gender	Age group (years)					p-value
	11 – 20	21 – 30	31 – 40	41 – 50	51 – 60	
Male (M)	15.6±4.3	20.4±3.7	18.4±6.1	16.2±3.1	14.3±3.3	0.021
Female (F)	12.2±4.0	14.8±5.0	16.1±3.6	15.0±2.2	15.6±3.0	0.148
Total (M+F)	13.9±4.4	17.6±5.0	17.3±5.0	15.6±2.7	15.0±3.1	0.031

Data were analyzed using ANOVA statistics and were presented as mean ± SD.

The volume of the left maxillary sinus

In the left maxillary sinus, the highest volume was also found in respondents aged between 21-30 years and the smallest between 11 – 20 years. The difference in the volume of the left maxillary sinus in relation to age was statistically significant ($p < 0.05$). In males, the distribution of the volume of the left maxillary sinus was significantly heterogeneous with respect to age, with the highest volume being observed in the age group 21 – 30 years and the lowest being in 51 – 60 years ($p < 0.05$). In females, the highest values were observed in the 21-30- and 31-40-year age groups and the lowest was seen in the 11-20 years age groups. The difference in the volume of the left maxillary sinus in relation to age in females was found to be statistically significant ($p <0.05$) (Table 2).

Table II: Distribution of volume of left maxillary sinus according to gender and age (Mean ± SD, cm^3)

Gender	Age group (years)					p-value
	11 – 20	21 – 30	31 – 40	41 – 50	51 – 60	
Male (M)	17.7±4.5	21.2±4.6	16.4±5.1	16.9±3.1	15.0±3.7	0.035
Female (F)	12.0±2.8	16.8±4.2	16.8±3.9	15.1±3.1	15.0±2.9	0.022
Total (M+F)	14.9±4.7	18.9±4.8	16.6±4.4	15.9±3.1	15.0±3.2	0.014

Data were analyzed using ANOVA statistics and were presented as mean ± SD.

Comparison of the volume of maxillary sinus between males and females

The mean (± SD) volume of the right maxillary sinus in males and females were 17.0 (± 4.6) and 14.7 (± 3.7) $cm^{3,}$ respectively, and the difference between them was found to be statistically significant ($p < 0.05$). The mean volume of the left maxillary sinus in males and females was 17.5 (± 4.7) and 15.1 (± 3.7) cm^3,

respectively, and the difference between them was found to be statistically significant ($p < 0.05$). The comparison of the mean of the maxillary sinus volume between the two groups was made by an unpaired t-test (Table 3).

Table IV: Comparison of the volume of maxillary sinus between males and females

The volume of maxillary sinuses in cm^3	Gender		p-value
	Male (n = 50)	Female (n = 50)	
Right	17.0 ± 4.6	14.7 ± 3.7	0.008
Left	17.5 ± 4.7	15.1 ± 3.7	0.006

Discussion

Maxillary sinuses originate as an invagination of the nasal mucosa into the maxilla bone. When deciduous teeth fall off at the end of the second embryonic month, these sinuses extend to the roof of the permanent teeth. This unique development narrates the large quantity of anatomical variation.[9] It is recognized that the maxillary sinuses appear in most individuals up to the age of five, and due to the development of the permanent dentition until the age of 18-20, these sinus area undergoes changes in shape and volume.[10]

An good imaging technique for evaluating the sino-nasal cavities is the CT scan. They provide a precise assessment of the paranasal sinuses, craniofacial bones, and the degree of sinus pneumatization.[11] It has been discovered that the maxillary sinus varies across individuals and, additionally, between males and females. Additionally, the maxillary sinus varied depending on the ethnic group.[6]

In this study, the volume of the maxillary sinus was found to be more among males when compared to females, which was statistically significant ($p < 0.05$). There have been mixed findings regarding the maxillary sinus volumes in other studies. The maxillary sinus volume appeared to be larger among males, but in females, their recorded volume was consistent with the present study.[2,12] In contrast, other studies have revealed lesser volume in males and females when compared with the current study.[3,13]

In general, the volume of the maxillary sinus in relation to age is statistically significant ($p < 0.05$), with the only exception in this study being the volume of the right maxillary sinus volume in females ($p = 0.148$). The greatest maxillary sinus volume was exhibited between 21-30 years of age, both on the right and left side. Another article found similar findings where the mean (±S. D) in a male was 24.04 (±5.72) cm^3, and in females, 15.86(±7.38) cm^3 was the greatest volume in the 21-30 years of age group. The decrease in volume after this age may be caused by the loss of minerals in the bone matrix of the entire bony structure surrounding the maxillary sinus in all directions, which contracts the maxillary sinus.[2]

Thus, the variation of some of the results of maxillary volume among the different previous researchers and with the present study was probably due to a combination of many factors like different ethnic and racial groups with the differences in body stature, skeletal size, height, and physique of an individual, sample size, genetic and environmental factors, anatomical variation of sinus, the difference in osteoblastic and osteoclastic activity and pneumatization process of the sinus in different age and sex groups.[14,15]

There are some limitations observed in this current study. To begin with, the sample size was too small to represent accurate findings of the Rajshahi population. In addition, intra-observer variation, subject positioning, and subjective selection of the slice could have affected the accurate measurement of the maxillary sinuses.

Conclusion

This study on CT measurement of maxillary sinus volume will be beneficial for surgeons when planning for endoscopic sinus surgery, and it also widens the anthropometric knowledge for human

beings by establishing a reference database in our community. In addition, our database may assist in further developing clinically applicable Doppler equipment for the staging of rhinosinusitis.

Conflict of interest: None declared.

References

1. Amin MF, Hassan EI. Sex identification in Egyptian population using Multidetector Computed Tomography of the maxillary sinus. Journal of Forensic and legal medicine. 2012 Feb 1;19(2):65-9.
2. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to the aging process; volume assessment by 3-dimensional reconstruction by high-resolution CT scanning. Otolaryngology—Head and Neck Surgery. 2005 Mar;132(3):429-34.
3. Karakas S, Kavaklı A. Morphometric examination of the paranasal sinuses and mastoid air cells using computed tomography. Annals of Saudi medicine. 2005 Jan;25(1):41-5.
4. Uthman AT, Al-Rawi NH, Al-Naaimi AS, Al-Timimi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. Journal of forensic sciences. 2011 Mar;56(2):403-8.
5. Yoshino M, Miyasaka S, Sato H, Seta S. Classification system of frontal sinus patterns by radiography. Its application to the identification of unknown skeletal remains. Forensic Science International. 1987 Aug 1;34(4):289-99.
6. Fernandes CL. Volumetric analysis of maxillary sinuses of Zulu and European crania by helical, multislice computed tomography. The Journal of Laryngology & Otology. 2004 Nov;118(11):877-81.
7. Rhys Evans PH. The paranasal sinuses and other enigmas: an aquatic evolutionary theory. J Laryngol Otol 1992; 106:214–25
8. Stammberger H. Fuctional Endoscopic Sinus Surgery. Philadelphia: BC Decker, 1991:45–7
9. Kiruba LN, Gupta C, Kumar S, D'Souza AS. A study of morphometric evaluation of the maxillary sinuses in normal subjects using computer tomography images. Archives of medicine and health sciences. 2014 Jan 1;2(1):12-5.
10. Ahmed AG, Gataa IS, Fateh SM, Mohammed GN. CT scan images analysis of maxillary sinus dimensions as a forensic tool for sexual and racial detection in a sample of Kurdish population. European Scientific Journal. 2015 Jun 1;11(18):272-281.
11. Attia AM, El-Badrawy AM, Shebel HM. Gender identification from maxillary sinus using multi-detector computed tomography. Mansoura Journal of Forensic Medicine and Clinical Toxicology. 2012 Jan 1;20(1):17-28.
12. Sahlstrand-Johnson P, Jannert M, Strömbeck A, Abul-Kasim K. Computed tomography measurements of different dimensions of maxillary and frontal sinuses. BMC medical imaging. 2011 Dec;11(1):1-7.
13. Ariji Y, Kuroki T, Moriguchi S, Ariji E, Kanda S. Age changes in the volume of the human maxillary sinus: a study using computed tomography. Dentomaxillofacial radiology. 1994 Aug;23(3):163-8.
14. Sharan A, Madjar D. Maxillary sinus pneumatization following extractions: a radiographic study. International Journal of Oral & Maxillofacial Implants. 2008 Jan 1;23(1):48-56.
15. Sharma SK, Jehan M, Kumar A. Measurements of maxillary sinus volume and dimensions by computed tomography scan for gender determination. Journal of the anatomical society of India. 2014 Jun 1;63(1):36-42.

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