Para Nasal Sinuses are Pneumatized in a Synchronized Pattern, a Study Evaluating Volume of the Maxillary and Sphenoid Sinuses using Cone Beam Computed Tomography

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ABSTRACT

Introduction: The volume of the paranasal sinuses, especially maxillary sinuses is a crucial factor for diagnosing maxillofacial pathologies, dental implant planning, surgeries involving maxillofacial region etc. Study was done with the objective to determine the volume of maxillary and sphenoid sinus and to evaluate its correlation with pneumatization between them using cone beam computerized tomography (CBCT)

Material and methods: This cross-sectional study was conducted as a retrospective evaluation of CBCT images of 50 maxillary and sphenoid sinuses from patients who reported to the maxillofacial radiology department of college of dentistry, qassim university, saudi Arabia. The differences among gender, age, individual volume and volume pattern of the both the sinuses were statistically analyzed.

Results: The mean volume of the maxillary sinus was 10.0 cm^3 and mean volume of the sphenoid sinus was 8.6 cm^3. The comparison of the mean volumes of maxillary sinuses and sphenoid sinuses showed a statistically significant correlation. The correlation coefficient shows the value of $r = 0.58$ with a significance of 0.000. The relationship of volume of the maxillary sinus and sphenoid sinuses was found highly significant. There appears to be a synchronized variation in the volumes during different age groups.

Conclusion: The synchronized display of the pneumatization pattern of the para-nasal sinuses may be attributable to a conjoint assigning impact on the spatial organization in the entire skeletal ossification and pneumatization.

Keywords: Para Nasal Sinuses, Synchronized Pattern, Maxillary and Sphenoid Sinuses, Cone Beam Computed Tomography

INTRODUCTION

Assessing the volume of maxillofacial sinuses for establishing diagnosis and treatment planning in maxillofacial region is of utmost importance to the radiologist, otolaryngologists, maxillofacial surgeons and dentists for management of the pathologic basis of maxillofacial diseases.[1] The study has been undertaken to assess the volume of the maxillary sinuses and sphenoid sinuses. There are very few studies assessing the volume of the maxillary sinuses, therefore measuring volumes of the maxillofacial sinuses may help in numerous instances in medical diagnosis and especially dental otolaryngology. Perceptive notion of maxillary sinus and comparing the sinuses volume may be able to help knowing the proportional changes in general. Comparing the sinus volume may be able to help in assessing the maxillary posterior alveolar bone preservation after prolonged edentulousness; in implantology; in sinus pathology; and in surgical planning and management related to maxillary sinuses. Although the paranasal sinuses are mostly multifaceted arrangements, those arrangements are mostly adapted according to the functional mechanisms.[2] However, the pneumatization aids in lessening the overall mass of the skull, reduce the weight of the maxillofacial region, create mucus, and regulates the tonicity of the voice.[3] There are many significant size, shape and dimensional changes following the postnatal period, hence the age-related volume changes in the paranasal changes are subject of interest for surgical procedures.[4] The pattern of pneumatization of the various sinuses has always been a discussion in dealing with all the dental procedures and further it is not known to whether there is any configuration among different sinuses existing or not. Hence this study is undertaken to assess if any association exists in the pneumatization pattern of the maxillary sinus and sphenoid sinus.

MATERIAL AND METHODS

Cone beam computerized tomography was used to measure the volume of the maxillary sinus and sphenoid sinus volumes, the research sample consisted of 50 patients reported for CBCT scanning for various treatment at the College of Dentistry, Qassim University. The CBCT scans (Galileos, Field of view 12 x 15 x 15 cm3, 85 kvp, 5-7 mA, 14 s / 2 - 6 s seconds scan time/exposure time, Sirona Dental Systems LLC, 4835 Sirona Dr., Suite 100, Charlotte, NC

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For the purpose of the maxillary sinus volume measurement; maximum maxillary sinus height, maximum maxillary sinus width, and maximum the maxillary sinus length was used. And for the determination of the sphenoid sinus volume measurement, sphenoid maxillary sinus height, maximum sphenoid sinus width, and maximum the sphenoid sinus length was used.

The volume of the maxillary and sphenoid sinus was calculated according to the formula for volume of the shape of the sphere or shape of the pyramid.

1. V1 = 4/3 Πr3. (sphere volume)
2. V2= 1/3 A × h. (pyramid volume)

Volume of the maxillary and sphenoid sinuses were calculated by obtaining the mean of the sphere and pyramidal volume of the sinuses.

a) Maxillary sinus height (MSH): Maximal diameter of the maxillary sinus (in vertical plane) is defined as the lengthiest distance from the highest point of superior wall as obtained from the sagittal image

b) Maxillary sinus width (MSW): Maximal transverse diameter of the maxillary sinus (in horizontal plane) is defined as the longest distance perpendicular from the most prominent point of the medial wall to the most prominent point of the lateral wall as presented on the axial image.

c) Maxillary sinus length (MSL): Maximal anteroposterior diameter of the maxillary sinus (in sagittal plane) is defined as the longest distance from the most anterior point of the anterior wall to the most posterior point of the posterior wall on the axial image.

d) Sphenoid sinus height (SSH): Maximal diameter of the sphenoid sinus (in vertical plane) is defined as the lengthiest distance from the highest point of superior wall as obtained from the sagittal image

e) Sphenoid sinus width (SSW): Maximal transverse diameter of the sphenoid sinus (in horizontal plane) is defined as the longest distance perpendicular from the most prominent point of the medial wall to the most prominent point of the lateral wall as presented on the axial image.

f) Sphenoid sinus length (SSL): Maximal anteroposterior diameter of the sphenoid sinus (in sagittal plane) is defined as the longest distance from the most anterior point of the anterior wall to the most posterior point of the posterior wall on the axial image.

STATISTICAL ANALYSIS

Statistical analysis was performed with the Statistical Package for the Social Sciences 17 and the data was presented as mean, median, standard deviation, interquartile range with confidence interval 95% and standard deviation with a significance level of 0.05 and 0.001. Pearson correlation coefficient was used to assess the correlation between the sphenoid sinus and maxillary sinus in different age groups and among females and males.

RESULTS

The mean volume of the maxillary sinus was 10.0 cm^3. Median 9.79 cm^3, with a standard deviation of 4.1, Q1 (interquartile range) 7.3 and Q3 (interquartile range) 12.4, with a minimum range volume of 0.5 cm^3 to the maximum volume of 20.4 cm^3 (Table 1). According to the study, as age advances the volume of the maxillary sinus increased. Throughout the ages there was a uniform pattern of increase in sinus volume. After the age range of 51-60, the maxillary sinus volume showed lesser values and volume was reduced in later ages. (Table 2) (Figure 1). There is no difference in the volume of the maxillary sinus when the genders were compared, and it did not show statistical significance (Table 3). The mean volume of the sphenoid sinus was 8.6 cm^3, median 8.2 cm^3, with a standard deviation of 4.3, Q1 (interquartile range) 6.1 and Q3 (interquartile range) 11.7, with a minimum range volume of 0.9 cm^3 to the maximum volume of 23.6 cm^3 (Table 4). As age progresses the volume of the sphenoid sinus increases. Throughout the ages there

	Mean maxillary sinus volume
Mean	10.0
Median	9.7
SD	4.1
Q1	7.3
Q3	12.4
Minimum	0.5
Maximum	20.4

Table-1: Table Descriptive statistics for mean maxillary sinus volume

Age	Mean	SD	N	F	p
21 - 30	10.0	3.2	13	3.56**	0.009
31 - 40	10.7	3.6	15		
41 - 50	9.3	4.4	11		
51 - 60	16.1	4.7	3		
61 - 70	9.3	2.0	6		
71 - 80	2.7	3.2	2		

Table-2: Table: Comparison of mean maxillary sinus volume based on age

Gender	Mean	SD	N	t	p
Female	9.8	5.0	12	0.79	0.434
Male	10.8	3.3	38		

Table-3: Comparison of mean maxillary sinus volume based on gender

	Mean Sphenoid Volume
Mean	8.6
Median	8.2
SD	4.3
Q1	6.1
Q3	11.7
Minimum	0.9
Maximum	23.6

Table-4: Table Descriptive statistics for mean Sphenoid Volume

	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
Mean	7.9	8.5	9.7	9.0	10.7	1.1
Median	7.6	8.7	11.0	9.2	8.9	1.1
SD	2.8	5.7	3.3	2.9	4.2	0.3
Q1	6.5	3.7	6.2	6.1	8.1	0.9
Q3	8.6	10.9	12.4	0.0	14.6	0.0
Minimum	2.1	2.2	4.7	6.1	6.1	0.9
Maximum	13.8	23.6	13.8	11.9	17.8	1.3

Table-5: Table Descriptive statistics for mean Sphenoid Volume based on age

	r	Sig.
21 - 30	0.191	0.532
31 - 40	0.659**	0.008
41 - 50	0.721*	0.012
>50	0.725*	0.012

Table-6: Table Correlation between maxillary sinus volume and Mean Sphenoid Volume based on age

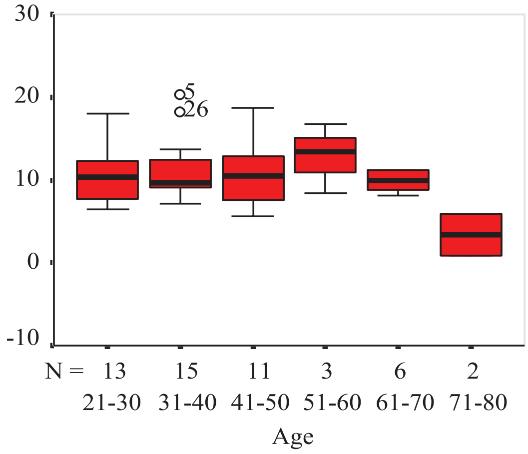

Figure-1: Box plot for mean maxillary sinus volume based on age

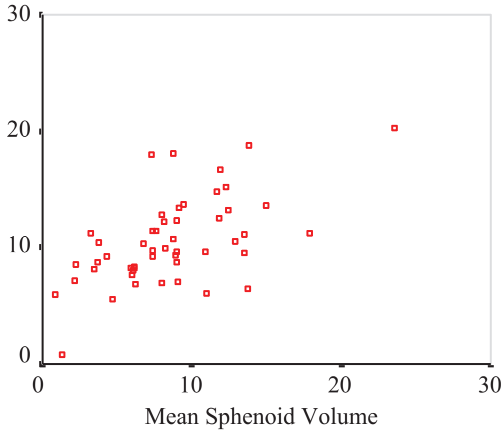

Figure-2: Scatter diagram for mMSV and Mean Sphenoid Volume

was a uniform pattern of increase in the volume. After the age range of 51-60 and after 61-70 age group sinus volume showed lesser values and volume was reduced in later ages. (Table 5). The comparison of the mean volumes of maxillary sinuses and sphenoid sinuses showed statistically significant correlation. The correlation coefficient showed the value of r = 0.58 with a significance of 0.000. (figure 2). As age increased the correlation coefficient r value was highly significant at the 0.001 level in the 31-40 age group with 0.05 significance in the 41-50 age group and > 50 group (Table 6) (figure 3). The maxillary sinus volume and the sphenoid sinus volume is highly correlated in the female and male groups at a significance level of 0.001. (figure 4)

DISCUSSION

Any benign or malignant pathology affecting the maxillary dentoalveolar complex are liable to affect the maxillary sinus. Therefore, measuring volumes of the maxillary sinus and understanding the pneumatization pattern of the maxillary sinus would be an inordinate assistance in forecasting specific variations for subsidiary treatment planning including dental, otolaryngeal and subsequent surgical management. The present study tried to categorize the volume of the maxillary and sphenoid sinus by calculating the pyramidal and sphere volume of the respective maxillary and sphenoid sinus with Cone beam computerized tomography. The mean volume of sphere and pyramidal volume was obtained to determine the original volume of the respective sinus. Several studies demonstrated variations in the volume when calculating sphere volume and pyramidal volume.[7] In this study, an approach was made to quantify the volume with the mean of both to obtain a closer range of volume mathematically.

The mean volume of the maxillary sinus was found to be 10.0 cm^3, median 9.7 unit, with a standard deviation of 4.1, Q1 (interquartile range) 7.3 and Q3 (interquartile range) 12.4, with a minimum range volume of 0.5 cm^3 to the maximum volume of 20.4 cm^3. This was is in concordance with other studies.[1,6] While it is known that the maxillary sinus attains its normal size by the age of 20 and remains as such after that;[8] it was shown that as age increases the volume of the maxillary and sphenoid sinuses increased in size and in later ages the volume subsequently reduced. There may be multiple factors influencing the volume of the sinuses, different mitigating factors of the bone remodeling and pneumatization, may be centrally coordinated.[9] The mean volume of the sphenoid sinus was 8.6 cm^3, median 8.2 cm^3, with a standard deviation of 4.3, Q1 (interquartile range) 6.1 and Q3 (interquartile range) 11.7, with a minimum range volume of 0.9 cm^3 to the maximum volume of 23.6 cm^3. In this study, as age progressed there was a uniform increase in volume till 61-70 years age and subsequently the volume was reduced in the age range of 71-80. This uniform increase in sinus volume till the age range of 61-70 was observed in the case of both maxillary sinus and sphenoid sinuses, and both sinuses showed a reduction in volume in later age group. Studies assessing volume of the paranasal sinuses

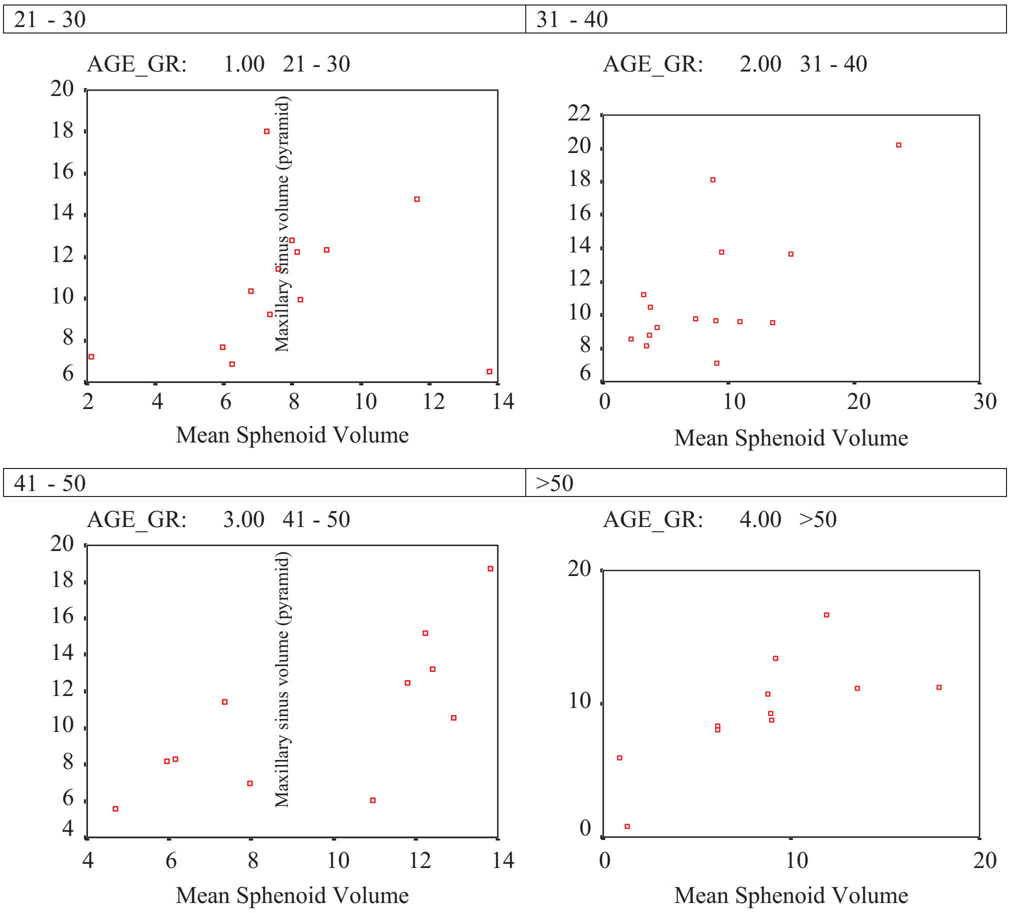

Figure-3: Scatter diagram for maxillary sinus volume and Mean Sphenoid Volume based on age

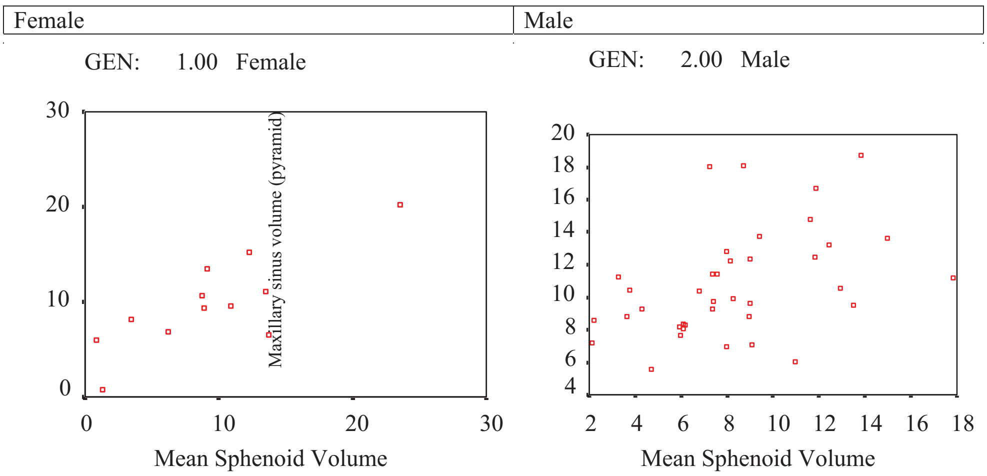

Figure-4: Scatter diagram for maxillary sinus volume and Mean Sphenoid Volume based on gender

has shown decrease in the volume as age progressed.[10,11] This attributable increase in middle ages and decrease in the later ages may be contributed by functional mechanisms of the jaws, dental factors and osteoporotic changes in the skeleton.

In this study, relationship of volume of the maxillary sinus and sphenoid sinuses was found to be highly significant with respect to the age. This appearance of synchronized variation in the volumes during different age groups may be unique documentation for the further research and conform a pattern. The comparison of the mean volumes of maxillary sinuses and sphenoid sinuses showed statistically significant correlation. The value of correlation coefficient r was 0.58 with a significance of 0.000. (figure 2). As age increased the value of correlation coefficient r became highly significant at the 0.001 level in 31-40 age group. The significance in 41-50 age group and > 50 group was 0.05 (Table 6) (figure 3). The maxillary sinus volume and the sphenoid sinus volume was highly correlated in the female and male groups at a significance level of 0.001. (figure 4). Thus, corresponding changes in the sinuses in the matching configuration may be a unique pattern resulting from adaptive changes and resulting from dominant feature in skeletal algorithm.

CONCLUSION

Learning sinus pattern in the study evaluated comparable variation in sinus configuration across different ages, a prime study in this area inclusive of all the sinus may result in the conclusive evidence in elaborating the pattern.

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