

Volumetric assessment of sphenoid sinus by 3D-CT scan in the age group of 10-22 years: A Cross-sectional study

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ABSTRACT

Background: Majority of medico-legal cases brought to the forensic specialist for assessment of age for both the victims and accused. Among newer technologies used for that Computed tomography (C.T. Scan) technology has become increasingly more accurate and precise.

Objectives: To find out ability of Computed tomography (C.T. Scan) for assessment of age in age group of 10-22 years

Material and Method: This study was carried out on 64 healthy subjects Sphenoid sinus was analyzed in coronal and axial position followed by 3-dimensional reconstruction in CT scan. Volume of Sphenoid sinus was assessed and significance of difference of volume of Sphenoid sinus as per age, sex and diet was assessed with Analysis Of Variance (ANOVA) and Post-hoc tests.

Result: Although age wise volumetric measurement of sphenoid sinus through CT scan was found significant in only some age groups when estimated at one year interval from 10-22 years but when estimated at interval of two years interval it was found significant for most of ages. Volumetric measurement of sphenoid sinus through CT scan at the interval of 4 years was found significant in every age group. Significance of difference in volumetric measurement of sphenoid sinus as per sex, residence was found significant along with age but as per type of diet it was not found significant when assessed by age interval of 2 years.

Conclusions: Age wise volumetric measurement of sphenoid sinus through CT scan can be found correct for most of ages from 10-22 years at interval of 2 year of age. Age can be estimated 100% volumetric measurement of sphenoid sinus through CT scan at the interval of 4 years from 10-22 years.

Key words: Sphenoid sinus, Age estimation, Computed tomography (C.T. Scan)

BACKGROUND

Age estimation in living is a commonly encountered problem of forensic practice all over the world. In the developing world, birth records may not be issued either promptly or not at all; and are frequently not stored in an efficient manner, thereby necessitating age estimation at any given age. Establishment of identity of an individual is of utmost medico-legal significance, both in living and dead, especially in cases of impersonation, murder or mass disaster, where the bodies are grossly mutilated or in advanced stage of decomposition.¹ Majority of medico-legal cases brought to the forensic specialist for assessment of age for both the victims and accused involved in cases like child labour, rape, kidnapping, abduction, judicial punishment and to establish the juvenile status, giving valid consent, for employment, child marriage, child trafficking etc.

The application of modern radiological techniques in age estimation of cases is yet used restrictively in this field, probably due to high cost and tedious reporting methods. Computed tomography (C.T. Scan) technology has become increasingly more accurate and precise.² Skull bones are commonly radiographed for the purpose of age assessment in the individuals who have more than 20

to 25 years of age. Among the paranasal sinuses, the last sinus to cease growth is the sphenoid sinus which shows maximum growth in the age group of 10 to 22 years that is important from a medico legal point of view.^{3,4} Radiology is a vital investigative technique that can be utilized for establishing age in both the living and the deceased individual. The non-invasive nature of radiology, in addition to its availability, makes it an ideal and preferred investigative method for the estimation of age.⁵

Computed tomography (C.T. scan) technology has become increasingly more accurate and precise.² Newly developed technologies involving modeling and visualization techniques have become essential research tools in many scientific and creative disciplines.⁶ Thus the present study has been undertaken to find out the application of measurements of the volumetric data of Sphenoid sinus as a tool for age assessment in the age group 10-22 years. In this study, volumes of sphenoid sinus have been measured using 3-Dimensional CT(3-D, C.T. Scan) in relation to increasing age.

MATERIAL AND METHOD

After taking approval from Institutional Ethics committee, SMS Medical College, Jaipur, this

crosssectional study was carried out in the Department of Forensic Medicine & Toxicology, in conjunction with the Department of Radio-diagnosis and Modern Imaging, S.M.S. Hospital, Jaipur during the period from October 2011 to February 2013. Subjects were selected randomly from patients of age 10-22 years visiting hospital during study period. Subjects not having documentary proof of age and subjects, who had either genetic, endocrinological, metabolic and bone marrow diseases or some chronic infectious pathology of Sphenoid sinus were excluded from the study. Even subjects with history either supra-said diseases or traumatic incidence resulting in fracture of paranasal sinuses were also excluded from this study.

Finally this study was carried out on 64 healthy subjects after taking informed written consent and obtaining documentary proof of date of birth, CT scan for volumetric assessment of Sphenoid sinus was done of all those identified subjects. Sphenoid sinus was analyzed in coronal and axial position followed by 3-dimensional reconstruction. After lateral scenograms the examinations for the sphenoid sinus consisted of 5 mm axial cross sections.⁷Height weight along with breadth of Sphenoid sinus was assessed of each subject through 3D-CT scanning. The extent of aeration (volume) was assessed on

reformatted sagittal and coronal images. Axial views and multiplanar reconstructions were used to identify the sphenoid sinus' dimensions. Data thus collected was collected in MS excel 2007 worksheet in the form of master chart. For the ease of the study the subjects were grouped into different age groups as the principle denominator at interval of 1, 2, 3 and 4 years from the documents obtained for the purpose of comparison. Significance of difference of volume of Sphenoid sinus as per age, sex and diet was assessed with ANOVA and Post-hoc test.

RESULTS AND DISCUSSION

In this cross sectional study, these 64 subjects studied were with mean age 17.17 ± 3.38 yrs with age range 10-21 yrs. (Figure:1). Male to female sex ratio was observed 1.56:1. (Table 1). Mean sphenoid volume of the subjects were 9.08 with SD 2.45 cm³. The measurements for all the three dimensions of the sphenoid sinuses were calculated in all the cases for either of the gender: In female-mean height was 21.216 ± 3.1748 mm; length 27.45 ± 4.5545 mm and width being 28.887 ± 3.6366 mm. and in male-mean height was 21.35 ± 1.3770 mm; length 28.467 ± 0 mm and width being 30.237 ± 3.2058 mm. (Figure:1)

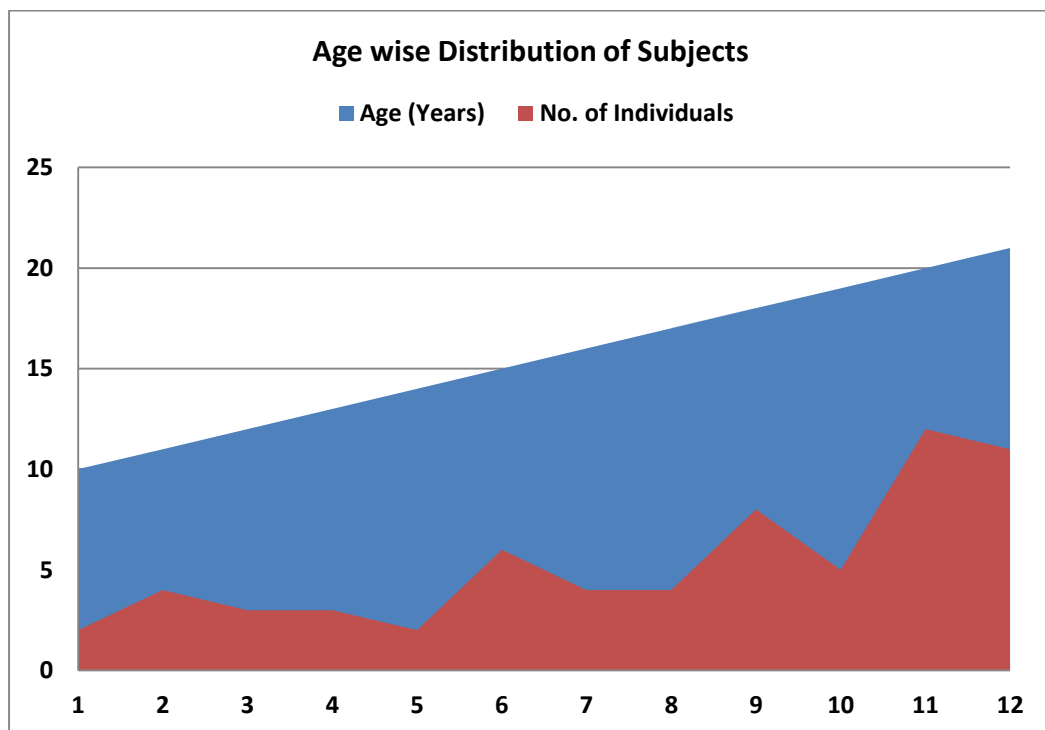


Figure 1

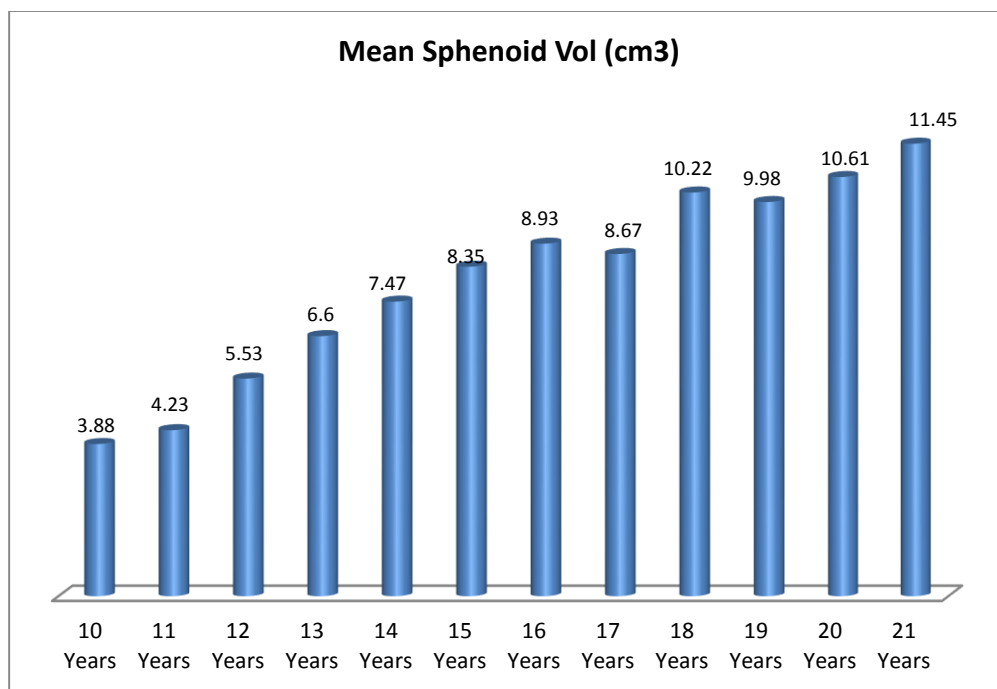


Figure 3

The mean volumes for different age groups were in increasing order from 3.88 ± 0.67 cm³ for 10 years to 11.45 ± 1.21 cm³ for 21 years with slight dip at 17 years where it was less than 18 years as well as 16 years. (Figure:2) Age wise volumetric measurement of sphenoid sinus at each age in years is significantly differ in some ages but not the all pairs observed significant. (Table1)

Table 1: Age wise volumetric measurement of sphenoid sinus at each age in years (N=64)

Group No	Age Group (Years)	Volume of sphenoid sinus (cm ³) (Mean \pm S.D) at age interval of 1-years		Significance (p<0.05) Difference in Age Groups	Not Significance (p \leq 0.05) Difference in Age Groups
		Mean	SD		
1	10 (N=2)	3.88	0.67	1 v/s 6,8,9,10,11,12	1 v/s 2,3,4,5,7
2	11 (N=4)	4.23	0.56	2 v/s 6,8,9,10,11,12	2 v/s 1,3,4,5,7
3	12 (N=3)	5.53	1.60	3 v/s 6,8,9,10,11,12	3 v/s 1,2,4,5,7
4	13 (N=3)	6.60	0.27	4 v/s 9,10,11,12	4 v/s 1,2,3,5,6,7,8
5	14 (N=2)	7.47	1.16	4 v/s 11,12	5 v/s 1,2,3,4,6,7,8,9,10
6	15 (N=6)	8.35	1.12	6 v/s 1,2,3	6 v/s 4,5,7,8,9,10,11,12
7	16 (N=4)	8.93	1.11	7 v/s 12	7 v/s 1,2,3,4,5,6,8,9,10,11
8	17 (N=4)	8.67	0.88	8 v/s 1,2,3	8 v/s 4,5,6,7,9,10,11,12
9	18 (N=8)	10.22	0.92	9 v/s 1,2,3,4	9 v/s 5,6,7,8,10,11,12
10	19 (N=5)	9.98	0.62	10 v/s 1,2,3,4	10 v/s 5,6,7,8,9,11,12
11	20 (N=12)	10.61	1.27	11 v/s 1,2,3,4,5,6	11 v/s 7,8,9,10,11,12
12	21 (N=11)	11.45	1.21	12 v/s 1,2,3,4,5,6,7	12 v/s 8,9,10,11,12
	ANONA	<0.001	S		

When, this age wise volumetric measurement of sphenoid sinus was observed at interval of 2 year of age, it was found significantly differ in most of age groups. (Table 2). So for assessing the significance of difference in age estimation with sphenoid volume as per sex, residence and diet was undertaken by age interval of 2 years.

Table 2: Age wise volumetric measurement of sphenoid sinus at Two Year age Interval (N=64)

Group No	Age Group (Years) *	Volume of sphenoid sinus (cm ³) (Mean ± S.D) at age interval of 1-years		Significance (p<0.05) Difference in Age Groups
		Mean	SD	
1	10 -12 (N=6)	4.11	0.56	2 v/s 1
2	12 -14 (N=6)	6.06	1.18	2 v/s 1
3	14 – 16 (N=8)	8.13	1.12	3 v/s 1,2
4	16 – 18 (N=8)	8.80	0.94	4 v/s 1,2
5	18 – 20 (N=13)	10.13	0.80	5 v/s 1,2,3
6	20 – 22 (N=23)	11.01	1.28	6 v/s 1,2,3,4
	ANONA	<0.001	S	

*10-12 means: above 10 years upto 12 years, 12-14 means above 12 years upto 14 years and likewise

In this present study, No study on application of the volumetric and other measurements of the paranasal sinuses as a tool for age assessment could be found even after exhaustive searching of the literature available in the libraries and on the internet. The mean value of mean sphenoidal volume for all subjects, including men and women in this study remained $9.0837 \pm 2.4505 \text{ cm}^3$. Yu HH et al, (2010)⁸ was observed lower volume ($7.97 \pm 3.12 \text{ ml}$) compared to these result.

Szolar D et al⁹ have reported mean values of 4.6 cm^3 for the age group of 10-12 years and 6.6 cm^3 for that of 12-14 years. Yu HH report volumetric measures of $7.97 \pm 3.12 \text{ cm}^3$. These values are similar to the values obtained in this study for nearly the same age.

The volumes of the sphenoidal sinus increased continuously with advancing age Our findings are in accordance to Scuderi AJ et al (1993)¹⁰ but they did not define the age limit of increase in the volume of the sphenoid sinuses and only found that the growth of the sinuses is continuous from childhood to achieve their final size till puberty. Also similar to our results are those of Yonetsua et al (2000)¹¹, Barghouth et al (2002)¹², Karakas S et al (2005)¹³, who have concluded that the sinus increases in size upto the age of 20 years, upto the third decade of life and upto 25 years of age respectively. But our findings are in contrast to Vogler et al (1998)¹⁴ and Reittner P et al (2001)¹⁵ who have reported that the sphenoidal sinus reaches adult size by the age of 12 years. Slight variations in volumetric measurements are quite explainable

owing to the different regions and time periods of the studies being compared to as racial, genetic, environmental and regional factors influence the development of growth of the paranasal sinuses as is well documented^{16,17}

In this study, the mean value of sphenoidal sinus volume for adult age group ranging from 18-22 years was 10.55 cm^3 which are slightly higher (8.7 ± 2.44 and 9.61 cm^3 , than those reported by Karakas S et al. (2005)¹³, Amusa YB et al (2005)¹⁸ respectively; and relatively lower (11.2 cm^3) than that reported by Pirner S et al (2009)¹⁹. The mean volume of sphenoid sinus is found more in male ($9.0837 \pm 2.4505 \text{ cm}^3$) than the female ($8.4102 \pm 1.955 \text{ cm}^3$). The mean volumes for different age groups for both sexes were obtained. The mean value in this study for an adult (18 to 22 years) male was $11.253 \pm 1.0346 \text{ cm}^3$ and that for the adult female was $9.6982 \pm 0.7526 \text{ cm}^3$. The mean volume of sphenoid sinus in females (10 to 22 years) was $8.4102 \pm 1.9595 \text{ cm}^3$ and that for males was $9.4878 \pm 2.6438 \text{ cm}^3$. The mean value for volume of the study was $9.0837 \pm 2.4505 \text{ cm}^3$. Similar data was computed for age intervals of three and four years as depicted in following two tables respectively.

The increase in the volume of the sphenoid sinus is also observed in either of the gender with increase in the age. The mean volumes for the rural populations were higher than those for the urban population being $9.2132 \pm 2.5607 \text{ cm}^3$ and $8.7255 \pm 2.1466 \text{ cm}^3$ Mean volume was higher for non-vegetarians being $9.555 \pm 1.9828 \text{ cm}^3$ than vegetarian being $9.0349 \pm 2.5033 \text{ cm}^3$. (Table 3)

Table 3: Age and Gender wise Distribution of Volumetric measurements of sphenoid sinus

Age Group (Years)*	Volume of sphenoid sinus (cm ³) (Mean ± S.D) at age interval of 2-years	
Total (N=64)	Female	Male
10 -12 (N=6)	3.9300 ± 0	4.144 ± 0.6190
12 -14 (N=6)	5.7175± 1.3608	6.753 ± 0.0070
14 – 16 (N=8)	7.9566± 1.3414	8.2296± 1.1266
16 – 18 (N=8)	8.3666± 0.7427	9.0596± 1.0165
18 – 20 (N=13)	9.3474± 0.4913	10.615± 0.5056
20 – 22 (N=23)	9.9175± 0.8308	11.594± 1.0939
ANONA (Sex wise)	<0.001S	<0.001S
	Urban	Rural
10 -12 (N=6)	3.87±0.5095	4.585±0.3323
12 -14 (N=6)	5.682±1.3210	6.824±0.1074
14 – 16 (N=8)	7.796±1.2143	8.6793±0.8527
16 – 18 (N=8)	8.6125±1.0799	8.987±0.8864
18 – 20 (N=13)	10.157±0.6936	10.06±1.1289
20 – 22 (N=23)	10.950±1.3299	11.645±0.0777
ANONA (Residence wise)	<0.001S	<0.001S
	Non-Vegetarian Diet	Vegetarian Diet
10 -12 (N=6)	-	4.1083 ± 0.5605
12 -14 (N=6)	6.2900 ± 0	6.0172 ± 1.3156
14 – 16 (N=8)	9.2400 ± 0	7.9682 ± 1.1106
16 – 18 (N=8)	-	8.7997 ± 0.9363
18 – 20 (N=13)	9.86 ± 1.8526	10.176 ± 0.6401
20 – 22 (N=23)	11.04±0.9333	11.008 ± 1.3302
ANONA (Diet wise)	<0.001S	<0.001S

*10-12 means: above 10 years upto 12 years, 12-14 means above 12 years upto 14 years and likewise

The mean volume of the sphenoid sinus was higher for the males as compared to the females of the same age group. Similar findings have been reported by Karakas S et al (2005)¹³, and Jefferson Oliveira Xavier (2009)²⁰. Our results are quite low for males and slightly lower for females when compared to the values reported by Jefferson Oliveira Xavier (2009)²⁰ {15.40±5.59cm³ for males and 10.88±3.83 cm³ for females}. These can be attributed to racial differences of the study population environmental variations of the study regions of both studies.

The mean length, width and height of sphenoid sinus in this study was 19.466 mm, 24 mm and 18.5 mm for 10-12 year age group respectively. Szolar D et al (1994)⁹ are quite in accordance with our finding in the age group 10-12 years. Reittner P et al (2001)²¹ has reported higher value of height, length and width of the sphenoid sinus than this study. The Austrian population is Mesati-cephalic (cephalic-index: C.I. = 75-80) and the Indian population is Dolicho-cephalic (cephalic-index: C.I. = 70-75) probably this variation might have contributed to the variations in the anatomical measurements of the sphenoid sinus.

The mean length, width and height of sphenoid sinus in this study was in adult age group was 31.4, 31.8 and 21.72mm respectively. Yu HH et al, (2010)⁸ has reported age related changes in sphenoid sinus on the basis of Helical computed tomography (3-D reconstruction C.T. scan) in 148

cases of Chinese population and found that the volume reaches mean volume at 15 years old. The mean length, width and height of sphenoid sinus was 22.93 ± 8.32, 33.09 ± 1.83 and 19.75 ± 6.12mm respectively. Our results are slightly variable for the dimension of height as compared to the values reported by Yu HH et al. (2010)⁸; for the dimension of width as compared to those reported by Elwany et al. (1983)²²; and for both height and width from the results of Sareen D et al. (2005)²³. The variations could have resulted due to racial differences, environmental and genetic variations in the study populations of different studies. Also slight differences can be explained as a part of observer bias for various studies (those who have made the measurements in various studies).

This study reports higher values of all dimensions and volumetric measurements in the urban and non-vegetarian study population for all age groups this may have resulted because of environmental and dietary variations as is expected from the results obtained. This study also reports that the volume of the sphenoid sinus increase with age along with the physical parameters of individuals which too increases with advancing age. However, no study discussing these variables could be obtained for comparison.

Accurate imaging and measurements of various dimensions along with volumetric assessments of the sphenoid sinuses can be considered as an important guide for age assessments

in the age group of 10-22 years in individuals with normal genetic development of sphenoid sinus, devoid of pathological involvement.

CONCLUSIONS

Age wise volumetric measurement of sphenoid sinus through CT scan can be found correct for most of ages from 10-22 years at interval of 2 year of age. Age can be estimated 100% volumetric measurement of sphenoid sinus through CT scan at the interval of 4 years from 10-22 years. Significance of difference in volumetric measurement of sphenoid sinus through CT scan as per sex, residence was found significant along with age but as per type of diet it was not found significant when assessed by age interval of 2 years.

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