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Frontal Sinus Pneumatization Pattern With Age

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Abstract
Understanding the mechanism of frontal sinus pneumatization depends on availability of accurate anatomical, physiological and pathological information in sufficient detail. It will also involve verification of certain prognostic factors, which may include simple anthropometric parameters. This study demonstrated the relationship between the variation in frontal sinus dimensions with age. In this study, lateral and anteroposterior radiographs of 74 males and 46 females between the ages of 9 and 75 years were measured. The three parameters of height, breath and length of the frontal sinus were taken from the radiographs. Data were analyzed using excel package of a tabletop computer, employing chi-square test (x^2) to determine the association between sinus dimensions and age. The results demonstrated a strong positive relationship between variation in sinus height and breadth (pneumatization in vertical portion of the frontal bone) with variation in age while variation in depth may not depend on age. Thus establishing the fact that some metric and morphologic characteristics of the frontal sinus vary with age. Therefore, it follows that advancement in age leads to increase in size of frontal sinus.

Keywords. Age, frontal sinus, pneumatization, morphometries

INTRODUCTION

The paranasal sinuses are cavities in the bones of the face and the cranium that contain air which function in speech and also serve to lighten the skull(Waugh and Grant,2005). The frontal sinus are between the outer and inner tables of the frontal bone, posterior to the superciliary arches and the root of the nose. The frontal sinus begins as an evagination of the anterior superior portion of the middle meatus known as the frontal recess. These bony air cells are produced in growth by the advancement of osteoclastic epithelial diverticulata; the resulting sinuses are found in the facial skeleton of both eutherian mammals and archosaurs (Rae et al; 2002). Extent of frontal sinuses varies among individuals and between the two sides. The pneumatization of the frontal sinus may extends in to the vertical part and the horizontal part of the frontal bone; extension into the roof of the orbit to the lesser wing of the sphenoid may also be present (Romanes, 1981). This results from an often irregular resorption of the diploe in the vertical portion of the frontal bone. Variation in frontal sinus may be attributable to both age and pathology. Variability due to the effect of age and pathology includes enlargement due to the thinning of frontal sinus walls which is in turn due to old age, post-menopausal symmetrical hyperostosis on the inner surface of the forehead causing reduction, chronic inflammatory conditions causing the thinning or thickening of the compact lamina and subsequent enlargement or reduction of the frontal sinus, injuries, tumors and obstruction of the front-nasal duct causing frontal sinus enlargement (Ezemagu et al;2005a). Trinkaus (1973) stated that the frontal sinus dimensions of Fontechevade 1 is an indicator of age. Showing that the inter-orbital breadth and frontal squamous thickness of Fontechevade 1, suggest juvenile status, while the size of the frontal sinus indicates a slightly older individual. In addition, variability due to sex and race are recognized (Stringer et a1; 1984) The dimensions of the frontal sinus are higher for males than females with mean length and width of frontal with previous sinus operation. sinuses as 35.36mm,

63.87mm for males and 28.70mm, 60.73mm for females respectively, in a population of South East Nigerians (Ezemagu et al; 2005a). European Neanderthal have a frontal sinus that extends laterally, not superiorly (Stringer et al;1984).

Since sinusitis affects more than 31 million people in the US and is the most common health care complaint in the country (Shankar,1994), information on pneumatization pattern of this structure may be useful. Also, understanding the manner of growth direction and approximate extent at any particular age is of importance in carrying out the operation of sinus wash out on children, for allowance must be made for the probable position of the sinus at any particular stage in its development (Colman,1992). In quest for aggressive medical management with a low index of suspicion for development of complications requiring surgical intervention, any additional information on metric and morphologic characteristics of frontal sinus aid otorhinolaryngologist and neurosurgeons in evaluation of sinuses.

Researchers in paleontology (Oyen et al; 1979) are concerned with the development of the supra orbital region. If it can be shown that supra orbital development involving frontal sinus is even partially correlated with certain sinus morphometries and that sinus pnuematization is correlated with age, it adds an additional factor to the puzzle of the meaning of supra orbital development.

MATERIALS AND METHOD

A total of 120 radiographs (74 males and 46 females) with age ranging from 9 - 75 years taken within 18'h August, 2003 and 12'h July, 2004 with lateral and Caldwell views were measured at Ebonyi State Teaching Hospital, Abakaliki, University of Nigeria Teaching Hospital Enugu and Hansa Clinic Enugu. Although the samples of radiographs used were collected from different places, the focus film distance used was the same (90cm as indicated from the centers where the samples were collected).

Radiographs of sinus used include those reported normal by the radiologists and those not affected by any pathological conditions or The three parameters measured were height, breadth and depth of frontal sinuses. The height and depth of the frontal sinuses were taken from the lateral view radiographs. Frontal sinus mostly appears as J shadow with its apex superiorly and basel floor inferiorly shown. The height was measured in vertical plane from the apex to the base. The depth or anteroposterior dimension was taken as the longest line perpendicular to the height and touching the anterior and posterior tables of the frontal sinus at its floor using the protractor and metric rule, because of its irregularly shaped floor.

The breadth of the frontal sinus was taken from the anteroposterior view radiographs. It appears as a crescent shaped shadow in this view separated in to two or three lobes by thin septa. Because of difficulty delimiting the inferior borders of the frontal sinus previous researchers have often drawn a base line tangential to the superior borders of the orbit (Francis et al; 1990, Ezemagu et al;2005a) The breadth was taken as the longest line parallel to the baseline touching the left and right lateral edges of the frontal sinus using the sets of squares and metric rule. In cases of smaller frontal sinuses, which may be partially or completely eliminated in these procedures, the parallel line was, taken midway between the baseline and the nasion (the midpoint of the nasofrontal suture).

RESULT

The relationships between age and height or breadth of frontal sinus as shown in Tables I and II showed that null hypothesis of no association should be rejected at a 0.01. The degree of dependency showed that about 70% and 69% of the variation in height and breadth of the frontal sinus respectively was related to variation in age. The relationship between age and depth of the frontal sinus as shown in Table III, was indicative of the fact that the evidence to reject the null hypothesis of no association was lacked at a 0.05. Also, the pattern of pneumatization shows that frontal sinus extend both superiorly and laterally but more laterally especially in females.

Table 1: Relationship of frontal sinus height and age

	Frontal Sinus Height (mm)								Total
		9 -16	17-24	25-32	33-40	41-48	49-56	57-64	
AGE GROUP (YRS)	9-15	4	1	2	2				9
	16-22	1	6	2					9
	23-29	2	5	9	9	3	2		30
	30-36		5	6	8	5			24
	37-43		2	3	7	3			15
	44-50			2	6	1			9
	51-57			3	3	1		1	8
	58-64			2		1		1	5
	65-71			1	2	3	3		9
	72-78					2			2
Total		**7**	**20**	**30**	**37**	**19**	**2**		**120**

Chi-Square Test

	Value	Df	Asymp. Sig (2-sided)
Pearson Chi-Square	114.231a	54	.000
Likelihood Ratio	89.051	54	.002
Linear-by-Linear Association	29.436	1	.000
N of Valid Cases	120		

* 65 cells (92.9%) have expected count less than 5. The minimum expected count is. 03.

x2 table value (0.01) =81.069.

Table II: Relationship of frontal sinus breadth and age

	Frontal Sinus Height (mm)								Total
		27-36	37-46	57-66	67-76	77-86	87-96	97-106107-117	
AGE GROUP (YRS)	9·15	5		1	1	1	1		9
	16-22	1	3	3	1	1			9
	23-29	1	2	8	8	6	4	1	30
	30-36			4	9	5	6		24
	37-43		2	4	2	4	3		15
	44-50			2	5	2			9
	51-57		1		1	3	2	1	8
	58-64			2	2		1		5
	65-71			1		2	5	2	9
	72-78			1		2			2
Total		**7**	**8**	**26**	**29**	**25**	**22**	**1** **2**	**120**

	Value	**U**	**Asynv. Sig (2-sided)**
Pearson Chi-Square	111.266	63	.000
Likelihood Ratio	84.993	63	.034
Linear-by-linear Association	16.030	1	.00
No. of Valid Cases	120		

*73 cells (91.3%) have expected count less than 5. The minimum expected count is. 02.

x2 table value (0.01) =92.01

		Frontal Sinus Height(mm)					Total
		4-8	9 -13	14 -18	19 - 23	24- 28	
AGE GROUP	9-15	6	3				9
	16-22	6	2	1			9
	23-29	8	11	7	3	1	30
	30-36	7	10	6	1		24
	37-43	3	8	2	2		15
	44-50	2	5	2			9
	51-57		3	4	1		8
	58-64		3	2			5
	65-71	1	2	3	3		9
	72-78			3			2
Total		**33**	**47**	**29**	**10**	**1**	**120**

Chi-Square Tests

	Value	IX	Asymp. Sig (2-sided)
Pearson Chi-Square	44.855*	36	.148
Likelihood Ratio	46.605	5 36	.111
Linear -by-Linear Association	14.950	1	.000
N of Valid Cases	120		

a 43 cells (86.0%) have expected count less than 5. The minimum expected count is. 02.

Xl table value (0.05) = 50.999.

Regression Analysis

The regression line for age and other variables with high value of correlation coefficient, using age as an independent variable shows that for age ≤15 years:

Male frontal sinus breadth 0.581age + 40.892
Male frontal sinus height 0.243 age + 29.324
Female frontal sinus breadth 6.409 age - 30.955
Female frontal sinus height 2.977 age - 19.614
It also showed that for all ages in the sample that there is no regression line to explain the variation.

DISCUSSION

The study showed that the frontal sinus depth may not vary with age but the relationship between age and height or breadth of frontal sinus, which are in the vertical portion of the frontal bone showed that null hypothesis of no association, should be rejected. There is a high degree of dependency between variation in height or breadth (vertical portion of the sinus) and age. Therefore, it follows that advancement in age leads to increase in size of frontal sinus. The development of frontal sinus is the result of two simultaneous processes; the progressive advancement of the sinus mucosa and concomitant resorption of the overlying bone or an often-irregular resorption of the diploe in the vertical portion of the frontal bone (Ezemagu et al; 2005a). Rae et al (2002) staten that the development of frontal sinus is due to the advancement of osteoclastic epithelial diverticulata. The functions of paranasal sinuses which include lighten the skull, was supported by this finding since pneumatization will reduce the weight .of the skull bone. There is increasing pneumatization of maxillary sinus at the rate of 2mm and 3mm per year for eight years in the vertical and anteroposterior planes respectively (Ezemagu et al; 2005b). Also, the transverse limit of expansion is reached in ninth year, when the sinus penetrates the molars bone , thereafter progress is slow and ceases at 15years, except the inferior angle, which descends after eruption of the third molar. Shankar (1994) stated as follows; the frontal sinus undeveloped at birth appears in the second year as a result of the pneumatization of the anterior portion of the frontal recess or from an anterior ethmoid cell, frontal sinus usually reaches adult size by age 18, and may continue to grow slowly throughout adulthood, by the middle of third year, cupola of the sinus appears above the level of nasion, by eight years of age the superior border extends to the height of the supraorbital rim and by ten years of age, it may reach superiorly into the supercilliary region. From the regression

analysis of this work, it follows that pneumatization of male frontal sinus breadth reach the size of 46.121mm at age 9 and increase at the rate of O.581mm per year till age 15. Male frontal sinus reach the height of 31.511mm at age 9 and increase at the rate of 0.243 per year till age 15. Female frontal sinus breadth reach the size of 26.726mm at age 9 and increase at the rate of 6.409mm per year till age 15. Also, female frontal sinus reach the height of 7.179mm at age 9 and increase at the rate of 2.977mm per year till age 15 This result therefore shows that frontal sinus extend both superiorly and laterally but more laterally especially in females. Also, it demonstrated a strong association between age and height or breadth of frontal sinus, though could not demonstrate a linear relationship for age above 15.

Clearly, additional tests are necessary to explore the role played by genetic and epigenetic factors in the morphology of the paranasal sinuses.

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