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RESEARCH ARTICLE

SEXUAL DIMORPHISM OF PEDIATRIC SKULL MORPHOMETRY AND THE PREDICTION OF BI-PARIETAL DIAMETER USING RETROSPECTIVE DIGITAL X-RAY FILMS IN CALABAR, NIGERIA

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Abstract

Introduction: The knowledge on the morphology of the pediatric skull has proven to be very useful in medical sciences as it aids in diagnosis of certain head injuries/pathologies. This study is aimed at determining the difference in dimension between the male and female pediatric skull with respect to age as well as predicting the bi-parietal diameter of the pediatric skull using the anterior-posterior diameter and age as constants.

Methods: The research was carried out at the University of Calabar Teaching Hospital and Asi Ukpo Medical Diagnostic Center, making use of x-ray films in retrospect with measuring tools in order to properly measure and record data collected. SPSS was used for statistical analysis. There was a significant correlation between age and APD/BPD at $p<0.05$. A regression analysis was used to predict the bi-parietal diameter of the pediatric skull.

Results: Our study show that the male pediatric subjects have a moderately higher skull dimension compared to the females with a progressive increase in the dimensions of skulls of both genders as age increases. The regression analysis predicts the bi-parietal diameter and was validated using the equation.

Conclusion: In conclusion, we found that the male pediatrics skull dimensions are higher when compared to that of the female, moreover, the dimensions of the male pediatric skull is shown to grow at a faster rate than female subjects and the biparietal diameter can be predicted using antero-posterior diameter and age as constants.

Introduction:-

The pediatric skull morphometry is useful in monitoring the developmental progression as well as detection of several pathologies or disease[1]. It is of mesenchymal origin which then ossify through intramembranous ossification. Morphologically, the size and shape of the pediatric skull changes significantly with age and head circumference. The skull thickness and width vary with age, head circumference and location, which will have important effects on skull morphology and injury prediction[5].

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The skull is divided into two distinct portions which are the neurocranium, that surrounds the brain and special sense organs, and the viscerocranium which forms the lower face and jaws. The neurocranium is further divided into the membranous neurocranium which forms the cranial vault and the cartilaginous neurocranium which forms the skull base[4,10]. In newborns, the membranous bones of the vault are separated by the intervening sutures. Where the sutures intersect, they widen and assume the shape of fontanelles[3].

At birth, the volume of the neurocranium is eight to nine times greater than that of the face. The ratio is 5:1 at 2 years, and further reduces to 3:1 at 6 years and 2:1 in adulthood. The ratio of cranium to facial bones is 4-4.5 at birth and decreases with age where it becomes 3-3.5 at age 2 years, 2.5 at 6 years and 1.5-2 in adulthood[2,3].

A thin pliant skull and patent sutures predispose the head of the newborn to large shape changes during external loading. These structural features are necessary during birth, where quasistatic head molding allows the passage of the head through the birth canal with minimal trauma. However, these same structural features leave the skull of the newborn with little ability to resist and absorb the large energies associated with traumatic loading[6].

Previous studies on pediatric head geometry mainly focused on global dimensions, such as the head length, width, height, and circumference by measuring a large number of volunteer subjects[8]. Detailed information on 2-dimensional size and shape, suture width, and skull thickness of pediatric heads as well as their variations among children with different ages are largely lacking. Another study that shows a statistical skull geometry model for children 0-3 months was developed based on head computed topography scan data from 11 subjects[11]. The study was limited to developing a parametric pediatric head finite element model, so the morphological details, including head size/shape, skull thickness and sutures width were not presented quantitatively [(3).]

In order to extend the age ranges with more subjects and better represent the morphological variations for pediatric skulls, Zhigang et al., 2015 studied an improved statistical model of skull geometry, developed it based on landmark data extracted from head computed topography scans that is valid for a larger range of ages 0-3 years and better considers the effects of variations in head size/shape, suture width and skull thickness[11].

Further contribution of this recent study is the characterization of skull thickness in almost all previous pediatric head finite elements model which were assumed to be constant. For example, the skull thickness values of the newborn head in some studies by (Da costa et al., 2012) and (Ross et al., 2010) were assigned as 1.2mm and 1.4mm, respectively. The values are slightly lower than the average value reported. The skull thickness of the 3-year-old head model in a study was 4mm, which is fairly consistent with the average skull thickness of the 3-year-old children in current studies[7]. However, considering the relatively large variation found in skull thickness at different locations, a single value is probably not enough to describe the skull thickness distribution in children and a uniform change in skull thickness cannot represent the skull thickness variation either[5].

Radiologic samples of the infant skull is of great importance as it can serve as a determining factor for fractures, birth abnormalities, infections, presence of foreign bodies, tumors, sinus disease and also metabolic and endocrine disorders that cause bone defects of the skull[8].

Materials and Methods:-

Materials:-

Materials used are; Computers, X-ray films, DICOM viewer, rewritable disc, flash drives, plain papers, pencils, pen, meter rule.

Methods:-

Research design

The study is a retrospective analytical study, using x-ray films obtained within the University of Calabar Teaching Hospital and Asi Ukpo diagnostic center Calabar.

Sampling

A random sampling technique was employed for the study every member of the desired population (pediatric age group) had an equal chance of being selected. A sample size of 90 pediatric skull radiographs was used in the study.

Data collection method

Pediatric skull radiograph was obtained with patients lying in a supine position. Using the DICOM installed in the computer, the x-ray of the skull of patients were taken following visit to the diagnostic centers and was measured accordingly using the application's measuring tools and the values obtained were carefully recorded in a table format. Measurement of the occipitofrontal diameter was taken from point of glabella anteriorly to the posterior occipital protuberance while measurement of the bi-parietal diameter was measured from the mid-point of the parietal bone on either side. (Figure 1 and 2). Measured data was recorded as follows; patient's age, gender, antero-posterior dimension of pediatric, and bi-parietal dimension of pediatric skull.

Inclusion and exclusion criteria

X-ray film images with a 1mm slice thickness of patients residing in Cross River State Nigeria and between the ages of 0 to 12 years was used.

Xray films of patients with a history of skull trauma, or skull pathologies such as Achondroplasia or Arnold Chiari Syndrome, that could compromise the accuracy of the study as well as X-ray films that were not clear were excluded from the study.

Statistical analysis

Statistical package for social sciences (SPSS) was used to analyze the obtained data.

Also using a 2 tailed Pearson's correlation, the relationship between antero-posterior diameter and bi-parietal diameter of both genders was done.

A regression analysis was used to derive a prediction equation for predicting bi-parietal dimension of pediatric skull using the antero-posterior dimension and age as constants.

Figure 1:- Measurement of anterior-posterior diameter of pediatric skull using the DICOM app tools.

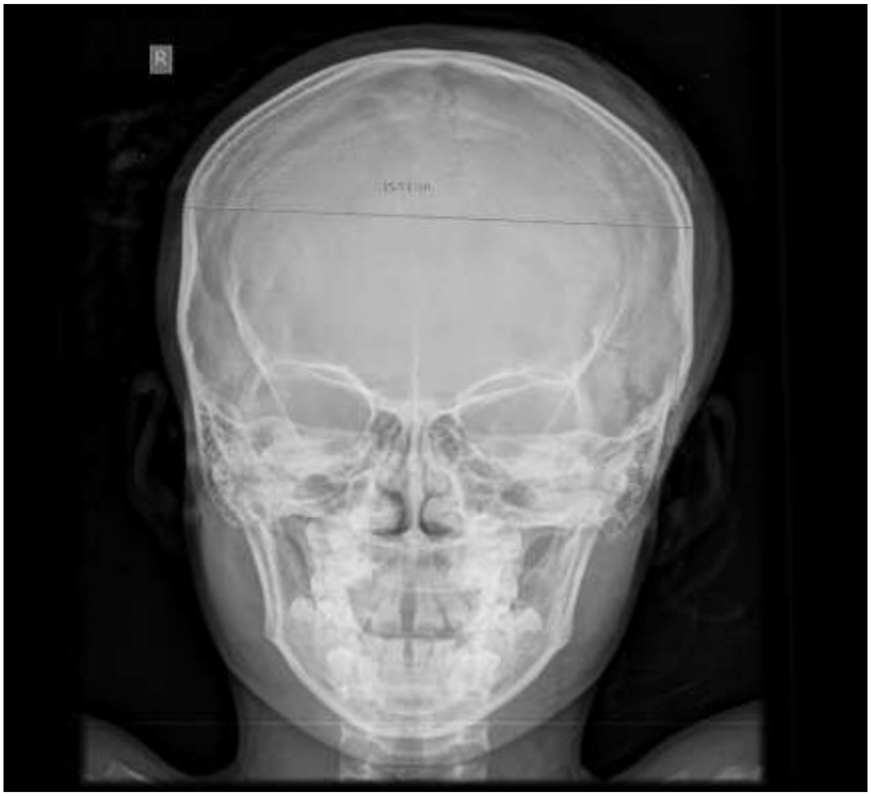

Figure 2:- Measurement of bi-parietal diameter of pediatric skull using the DICOM app tools.

Results:-

Table 1:- Summary statistics of dimensions of paediatric skull of male and female subjects.

	Gender	N	Mean	SD	SEM	p-value
Age	Male	54	5.92	4.19	0.57	0.039
	Female	36	7.82	4.28	0.71	
APD	Male	54	16.90	2.31	0.31	0.658
	Female	36	16.70	1.70	0.28	
BPD	Male	54	12.44	1.76	0.24	0.761
	Female	36	12.33	1.88	0.31	

Table 2:- Relationship between age and the dimensions of pediatric skull of male and female subjects.

Gender	Parameter	Antero-posterior dimension	Bi-parietal dimension
Males	Pearson Correlation	.603**	.563**
	Sig. (2-tailed)	0	0
	N	54	54
Female	Pearson Correlation	.551**	.660**
	Sig. (2-tailed)	0	0
	N	36	36

** = Correlation is significant at $p<0.05$

Table 3:- Equation for Prediction of bi-parietal dimension of pediatric skull using age and antero-posterior dimension.

Gender	Prediction equation
Males	1.059 + Age (0.013) + APD (0.669)
Females	-2.893 + Age (0.101) + APD (0.864)

Age in year and APD (cm)

Table 4:- Testing of prediction equation.

	Observed	Predicted	p-value
Males	12.44	12.44	0.994
	±0.24	±0.21	
Females	12.33	12.33	0.999
	±0.31	±0.29	

Discussion:-

The pediatric skull geometry indicates that growth are more rapid in length (antero-posterior diameter-APD) than in its width (biparietal diameter-BPD) which presents the head as being dolichocephalic hence, conforms to a study carried out by Gajawelli et al, 2017 on the cranial growth of children 6 to 12 months of age whose result showed higher growth rate in length of pediatric skull at about 2.84% as compared to width growth.

Our study shows that the APD is slightly higher in males than females with SD of 2.31 against 1.70 in females. Similarly, the BPD is minimally higher in male than female pediatric skull with an SD of 1.76 and 1.88 respectively.

This finding agrees with previous studies that inferred that male skull geometry has higher values than that of their female counterparts although these documentations were more specific in adult population.furthermore, from our study, we found that there is a strong correlation between age and APD and BPD in both genders. As age increases, there is a consequent increase though minimally in the pediatric skull dimensions. This follows through the identified changes in the pediatric skull during development and closure of the fontanelles leading to a definitive skull morphology.

The regression analysis proved a very useful tool to predict the bi-parietal diameter of pediatric skull using values gotten from the measurement of the antero-posterior diameter and the pediatric age. This type of analysis was equally adopted by Hahn et al, 1984 where they studied cranial growths in pediatrics. This analysis used had a significance value of +2 or -2, having being tested with at least 10 antero-posterior diameter measurement of each gender.

Measuring the BPD accurately is a bit cumbersome due to non-specificity of the parietal bone's midpoint. It is mostly user dependent hence, the need to derive a prediction equation to accurately predict the BPD using age and APD as constant variables as shown in tables 3 above. Our derived equations were subjected to a statistical test as shown in table 4 and outcome was indicative of a near accurate values when compared between the observed (measured) and the predicted values in both genders at p-values of 0.994 and 0.999 for both males and females respectively. Hence, validates the derived equation through our regression analysis.

Overall, the dimension of the pediatrics skull is slightly larger in males than in females as shown in their mean values. Nevertheless, Rodrigues et al, 2008 observed no significant difference between the overall dimensions of pediatric subjects. However, there is a minimal deviation from our study as male pediatric skull shows slightly higher dimensions than females especially when only the anterior-posterior dimension is considered independently as initially stated.

Conclusion:-

Conclusively, X-ray films has proven to be a very useful tool in studying the morphology of pediatric skull as it aids the easy measurement of its dimensions. This study therefore, shows that males have a higher dimension than female counterparts in pediatric skull measurement with a more rapid growth in the anterior-posterior diameter than bi-parietal diameter. However, the bi-parietal diameter can easily be predicted using age and measured anterior-posterior diameter as constants.

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Conflict of interest

There is no known conflict of interest as this is original research paper and all authors cited have been duly referenced.

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