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MORPHOMETRIC STUDY OF SELLA TURCICA USING COMPUTED TOMOGRAPHY SCAN OF THE BRAIN IN KANO METROPOLIS, NIGERIA

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ABSTRACT

Background: Morphometric study of the Sella Turcica using computed tomography of the brain, provides knowledge about the anatomical structure of the Sella and para sella region.
Aim: To describe the linear dimensions of sella turcica among normal Nigerian adults in Kano metropolis, Northwest Nigeria.
Methodology: This prospective study was carried out at the Radiology department of Aminu Kano Teaching Hospital (AKTH) Kano, from May 2018 to April 2019. A total of 198 brain CT scans of adults within the age range of 18 – 75 years were recruited. Analysis for the differences between gender was done using the independent sample and Mann-Whitney tests to analyze for differences between gender while one-way ANOVA and Kruskal Wallis were used to check for association between age of subjects and the parameters recorded. Statistical significance was set at $P<0.05$.
Results: The study comprised 198 brain CT scans which constituted 127 males (64.1%) and 71 females (35.9%). The mean Sella Length, 10.83±1.68mm, Sella Width, 11.87±1.63mm, Sella Height Anterior, 8.89±1.66mm, Sella Height Posterior, 8.19±1.51mm, Sella Height Median, 8.59±1.67mm, Sella Depth, 7.96±1.47mm and Sella Antero-posterior Diameter, 13.41±1.81mm were obtained. A mean Sella Area of 87.14mm^2 was reported. Statistically significant difference was seen in most of the Sella turcica linear dimensions across age categories, but no significant correlation between Sella Area and Age.
Conclusion: The present study provides the normal values of sella turcica linear dimensions within an African population and can help in the objective assessment of Sella turcica enlargement.

INTRODUCTION

Morphometric studies of different races have almost always revealed variations and this established fact corresponds to ethnic variation and such variations of the bone are of clinical importance [1]. Anatomical variations are very important for medical education; it is paramount for surgeons to have a thorough understanding of the surgical region as this could alter diagnosis or treatment. The use of proper imaging techniques to detect these variations is essential [2].

The sella turcica also known as hypophyseal fossa is a saddle-like depression in the body of the sphenoid bone within the human skull that accommodates the pituitary gland [3]. The pituitary gland is the master endocrine gland of the

human body and controls other glands and secretes important hormones [4]. Sella turcica is an important structure in radiographic analysis of the neurocranial and craniofacial complex. Understanding normal morphology of the sella turcica is fundamental to describing abnormalities concerning the region which include the empty sella syndrome which is characterized by shrunken or flattened pituitary gland [5,6,7]. Identifying sella turcica variations helps in planning of surgery and avoiding injuries to the surrounding structures [8].
Computed Tomography (CT) is a non-invasive method of acquiring the images of the inside of the human body without superimposition of distinct anatomical structures, from a mathematical reconstruction of X-ray (ionizing radiation) attenuation measurements made through a thin axial slice of the patient [9, 10]. CT imaging is a powerful modality for central nervous system imaging and it has impeccable thorough depiction of bony structures [11, 12, 13]. There is a rapid rise in the use of CT for diagnostic decision-making [14] and morphometric studies using CT scan of the brain will add more insight and give objective assessment pattern of Sella turcica linear dimensions. This study was aimed at describing the linear dimensions of sella turcica among normal Nigerian adults in Kano metropolis.

MATERIALS AND METHODS

This prospective study was carried out at Muhammadu Sunusi (II) Radio-Diagnostic centre of the Radiology department of Aminu Kano Teaching Hospital (AKTH), located in Kano Metropolis, Nigeria using Helical Computed Tomography machine – 164 slice CT scanner Aquillion prime (Model TSX-303A, Toshiba Medical Systems Corporation) over a period of 12 months; from May 2018 to April 2019. A total of 198 brain CT scans of adults within the age range of 18 – 75 years were used for this study. Ethical clearance was obtained from the Research & Ethics committee of the Aminu Kano Teaching Hospital. The study involves subjects of Nigerian Nationality. All brain CT images were acquired with high quality CT volumetric data of the Sella turcica with utmost clarity and were reported by the reporting Radiologist(s). However, Subjects with previous history of plastic or reconstructive surgeries involving craniofacial or maxillofacial region, history of previous orthodontic or prosthodontic treatment, history of craniofacial deformities such as cleft lip or palate and any subject with findings of trauma or tumor (growth) involving the base of skull, craniofacial or maxillofacial regions were excluded from the study.

Scanning Protocol

All the Brain CT-scans were performed by an experienced and qualified radiographer, in a standardized conditions and manner, as described by the American Association of Physicists in Medicine [15]. The protocol for routine adult brain CT was designed to be in helical mode. The scan parameters were set at 120 kilovoltage (kvp) and 250 Milliampere (mA). In most cases automatic mA was prescribed due to its dose saving effect. The slice thickness in the scanner was set at 0.5mm for the adult brain. The analysis was made on the sagittal view of the bone window, using the coronal and axial views to manipulate and align for the sagittal section that is nearest to the mid-saggital plane as described by Turamanlar *et al* [8] and Abu Ghaida *et al.*, [16]. The average of three readings of each measurement was considered for the statistical analysis in order to minimize the intra-examiner variation.

Technique for measurements (as in Figure I):
Sella Length (SL): Line measuring the distance between tuberculum sellae (TS) and dorsum sellae (DS) points.

Sella Width (SW): Line measuring the longest antero-posterior length measured parallel from the most anterior and posterior points of sella turcica to the Frankfort horizontal plane (FH).

Sella Height Anterior (SHA): Line measuring the vertical distance measured from TS through sella turcica base to the FH plane.

Sella Height Posterior (SHP): Line measuring the vertical distance measured from DS through sella turcica base to the FH plane.

Sella Height Median (SHM): Line measuring the vertical distance measured from the midpoint between TS and DS to the FH plane.

Sella Turcica Antero-posterior Diameter (APD): Line measuring the distance from the TS to the backmost point in the interior surface of the posterior wall of the pituitary fossa

Sella Turcica Depth (SD): The length of the line drawn vertically from the deepest base of pituitary floor in the direction of the sella turcica length

Determination of Sella Area (SA): This was determined by obtaining the value, in mm^2, of the product of length and depth.

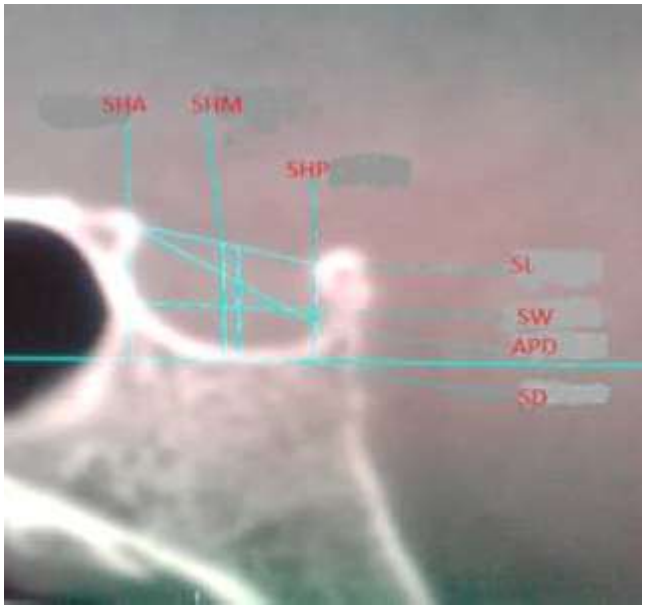

Figure I: Mid-sagittal Section of the Sella Area Showing Linear Measurements of Sella Turcica

Statistical Analysis

Data was recorded using a computer spreadsheet program (Microsoft Office 2010 EXCEL; Microsoft Corporation; Redmond, WA. USA). Discrepancies were queried and corrected. Data analysis was performed using a statistical software package SPSS, version 20 for Windows. Data was presented in tables and charts. Data was analyzed for descriptive statistics and represented as mean and standard deviations for continuous variables and as proportions/percentages for categorical data. Independent sample test and Mann-Whitney were used to analyze for differences between gender while one-way ANOVA and Kruskal Wallis were used to check for association between age of subjects and the parameters recorded. Statistical significance was set at $P<0.05$.

RESULTS

A total of 198 brain CT scans was used for this study; consisting of 127 males (41.39±15.16 age in years) and 71 females (40.10±15.63 age in years) Table 1. CT scans were certified normal and signed by a Consultant Radiologist. Participants between 18-25 years (first age category) had the highest frequency of n=48 with a percentage of approximately 24%. The least frequency was the participants between 66-75 years (sixth age category) with a frequency of n=6 and a percentage of 6% (Table 2)

Table 1: Distribution of Participants in the Study

Sex	Frequency (N)	Age (years) (Mean ± SD)
Males	127	41.39±15.16
Females	71	40.10±15.63
Mean	**198**	**40.92±15.30**

Participants between 18-25 years (first age category) had the highest frequency of n=48 with a percentage of approximately 24%. The least frequency was the participants between 66-75 years (sixth age category) with a frequency of n=6 and a percentage of 6% (Table 2).

Table 2: Distribution of Participants based on Age group.

Age (years)	Frequency(N)	Percentage(%)	Minimum	Maximum
1 (18-25)	48	24.2	18	25
2 (26-35)	37	18.7	26	35
3 (36-45)	36	18.2	36	45
4 (46-55)	34	17.2	46	55
5 (56-65)	37	18.7	56	65
6 (66-75)	6	3.0	66	75

In the present study, the overall mean Sella Length, Sella Width, Sella Height Anterior, Sella Height Posterior, Sella Height Median, Sella Depth, Sella Antero-posterior Diameter and Sella Area were determined to be 10.83±1.68mm, 11.87±1.63mm, 8.89±1.66mm, 8.19±1.51mm, 8.59±1.67mm, 7.96±1.47mm, 13.41±1.81mm and 87.14±24.81mm^2(Table 3).

Table 3: Total Mean Values for Sella Dimensions and Sella Area.

DIMENSIONS	MEAN±SD	MINIMUM	MAXIMUM
Sella Length	10.8±1.68mm	7.0mm	16.6mm
Sella Width	11.87±1.63mm	7.4mm	17.4mm
Sella Height Anterior	8.89±1.66mm	5.2mm	13.9mm
Sella Height Posterior	8.19±1.51mm	4.9mm	12.4mm
Sella Height Median	8.59±1.67mm	5.1mm	18.5mm
Sella Depth	7.96±1.47mm	5.0mm	13.0mm
Sella Antero-posterior Diameter	13.41±1.81mm	7.3mm	18.0mm
Sella Area	87.1±24.8mm^2	39.1mm^2	185.9mm^2

Also mean values of Sella Length, Sella Width, Sella Height Anterior, Sella Height Posterior, Sella Height Median, Sella Depth, Sella Antero-posterior Diameter and Sella Area for males were determined to be 11.01±1.56mm, 11.99±1.52mm, 8.80±1.68mm, 8.09±1.47mm, 8.52±1.75mm, 7.89±1.43mm, 13.47±1.82mm, 87.53±22.49mm^2 and for females were 10.51±1.86mm, 11.66±1.80mm, 9.06±1.61mm, 8.35±1.58mm, 8.70±1.53mm, 8.08±1.54mm, 13.30±1.81mm, 86.43±28.66mm^2 (Table 4).

Table 4: Mean Values of Sella Dimensions and Sella Area for Male and Female in the Study.

DIMENSIONS	MEAN±SD	
	MALE	FEMALE
Sella Length	11.01±1.56mm	10.51±1.86mm
Sella Width	11.99±1.52mm	11.66±1.80mm
Sella Height Anterior	8.80±1.68mm	9.06±1.61mm
Sella Height Posterior	8.09±1.47mm	8.35±1.58mm
Sella Height Median	8.52±1.75mm	8.70±1.53mm
Sella Depth	7.89±1.43mm	8.08±1.54mm
Sella Antero-posterior Diameter	13.47±1.82mm	13.30±1.81mm
Sella Area	87.53±22.49mm^2	86.43±28.66mm^2

This study used parametric tests for the normally distributed parameters and non-parametric tests for not normally distributed parameters. Table 6 shows the relationship between male and female with the independent sample test for Levene's test (parametric test) for equality of variances for SW and APD having a value of 0.157 and 0.951 ($p>0.05$). Table 7 shows Mann-Whitney test (non-

parametric test) for SHA, SHP, SHM, SD and SA with asymptotic significance (2-tailed) as 0.348, 0.301, 0.348, 0.400 and 0.347 ($p>0.05$). The SL is at 0.034 ($p<0.05$) which is the only dimension that shows statistically significant difference.

Table 5: Levene's Test for Sella Width and Sella Antero-posterior Diameter

VARIANCE	SIGNIFICANCE
SW	0.157**
APD	0.951

P-value <0.05 are statistically significant.

Table 6: Mann-Whitney U Test Values for Sella length, Sella Height Anterior, Sella Height Posterior, Sella Height Median, Sella Depth and Sella Area

	SL	SHA	SHP	SHM	SD	SA
Mann-Whitney U	3691.000	4145.500	4108.500	4146.000	4186.000	4144.500
Asymp. Sig. (2-tailed)	0.034**	0.348	0.301	0.348	0.400	0.347

P-value <0.05 are statistically significant.

The present study highlighted different mean values for patients within different age categories (Table 8).
Table 7: Mean Values of Sella Dimensions and Sella Area in Age Categories.

Age (yrs)	SL(mm)	SW(mm)	SHA(mm)	SHP(mm)	SHM(mm)	SD(mm)	APD(mm)	SA(mm^2)
1 (18-25)	10.19±1.71	11.39±1.64	9.36±1.90	8.72±1.48	9.05±1.61	8.45±1.59	13.26±1.92	87.63±26.66
2 (26-35)	10.90±1.78	11.39±1.51	8.52±1.65	7.81±1.71	8.17±1.64	7.52±1.61	13.51±1.60	83.12±27.38
3 (36-45)	10.79±1.51	11.56±1.58	9.03±1.51	8.12±1.52	8.84±2.23	7.87±1.39	13.12±2.01	85.27±24.04
4 (46-55)	10.84±1.68	11.98±1.85	8.20±1.43	7.85±1.18	8.00±1.19	7.59±1.09	13.23±1.85	83.67±20.47
5 (56-65)	11.66±1.43	12.64±1.43	8.98±1.33	8.04±1.36	8.52±1.26	8.06±1.37	13.88±1.52	94.22±22.46
6 (66-75)	10.63±1.76	11.76±0.94	9.95±2.08	9.40±1.72	9.66±1.81	8.66±1.52	13.85±2.31	95.10±32.00

The results showed an asymmetrical pattern of distribution for linear dimensional values. Differences between linear dimensions and area using age categories factor was established using one-way ANOVA (parametric test) for SW and APD. SW showed statistical significant difference ($p<0.05$) while APD did not show any statistical significant difference ($p>0.05$) with F-value of 0.014, and 1.27 respectively (Table 8). However, a post-hoc test using Bonferroni method across the various age categories revealed that in the SW, significant difference exists between the first and fifth age categories. While no significant difference exists across other age categories (Table 9). Kruskal Wallis Test (non-parametric test) was used to determine differences between dimensions of SL, SHA, SHP, SHM, SD and SA. Statistically significant difference ($p<0.05$) was noted for SL, SHA, SHP, SHM and SD. While no statistically significant difference ($p>0.05$) was noted for SA (Table 10).

Table 8: One-way ANOVA with Dimensional Differences in Age Categories

VARIABLE	SOURCE	F	p-value
SW	Age group	2.925	0.014**
APD	Age group	0.910	0.476

P-value <0.05 are statistically significant.

Table 9. Post-hoc Analysis of Dimensional Differences across Age Category Using One-Way ANOVA.

VARIABLE	(I)AGE CAT.	(J)AGE CAT.	SIGNIFICANCE
SW	1	2	1.000
		3	1.000
		4	1.000
		5	0.006**
		6	1.000
	2	3	1.000
		4	1.000
		5	0.852
		6	1.000
	3	4	1.000
		5	0.063
		6	1.000
	4	5	1.000
		6	1.000
	5	6	1.000

P-value <0.05 are statistically significant.
SW = Sellar width

Table 10: Kruskal Wallis Test for Dimensional Differences across Age Groups

	SL	SHA	SHP	SHM	SD	SA
Chi-Square	17.650	12.385	14.517	14.673	13.398	8.071
Df	5	5	5	5	5	5
Asymp. Sig.	0.003**	0.030**	0.013**	0.012**	0.020**	0.152

P-value <0.05 are statistically significant.

The study revealed the Sella Area to be not normally distributed. The Spearman correlation (non-parametric test) was used to check the correlation of Sella Area with Age. However, no significant correlation was established as the p-value was >0.05 (Table 11).

Table 11: Spearman Correlations of Sella Area with Age

VARIABLE	CORRELATION COEFFICIENT	SIGNIFICANCE
Age	0.117	0.099

P-value <0.05 are statistically significant.

DISCUSSION

Research on sella turcica linear dimensions has been conducted using various approaches by different researchers across the world. A study estimated the mean length of 9.81mm [17]. Also, another study reported mean length of 9.8mm [18]. Some studies reported Sella length as 10.31mm and 11.3mm respectively [19, 20]. Similarly, a value of 9.22mm and 9.52mm were respectively reported [21, 22]. These large differences in reported values with the present study can be explained due to the methodological approach as different measurements methods were adopted by different researchers.

The Sella Depth reported by some studies were 8.49mm, 8.6mmand 7.56mm respectively [17, 18, 21]. Likewise, 8.21mm was reported [22]. All these aforementioned reported values were similar to the present study as compared to 9.9mm reported [20]. However, the dimensional differences of the findings could be attributed to predictable differences in normal subjects included in the present study and abnormal subjects included in the study [20].

Also, Sella Antero-posterior Diameter was reported as 11.37mm [17], a study done in 2017 reported 11.5mm [18]. A report of 11.56mm and 11.48 was done in 2011 and 2015 respectively [21, 22]. These reported values are lower than that reported in the present study. Whereas, 13.9mm which is similar to that of the present study was reported in a study done in Islamabad, Pakistan [20]. Again, the similarities and dissimilarities could be due to different measurements methods.

Few studies were found on Sella Height Anterior, Sella Height Posterior and Sella Height Median. Nevertheless, of the studies performed, 7.41mm, 7.40 and 7.44 for Sella Height Anterior, Sella Height Posterior and Sella Height Median respectively was reported [7]. A report of 6.93mm, 6.61mm and 8.42 was stated respectively in Bangladesh [23]. Also, report of values of 11.83mm, 10.83mm and 10.54mm for Sella Height Anterior, Sella Height Posterior and Sella Height Median respectively was stated [8]. These values reported do not correlate with the present study. However, a matching pattern of distribution is noted between the present study and that done by Turamanlar [8]. Evidently, this similarity could be as a result of similar methodology adopted in both studies.

An expansive earlier study reported larger sella turcica in males than in females [24]. However, same study stated that during puberty, sella turcica in females is more prominent than in males. Likewise, a study described that during puberty, certain changes occur which causes swelling of the gland [25]. Conversely, the study established no significant difference between male and female. Larger Sella Length in Norwegian males than females with similar Sella Depth and Sella Diameter was reported between males and females [26]. No significant difference observed in studies involving an Indian populace [22, 27]. On the other hand, significantly higher values were observed for both Sella Length and Sella Width in males within a Turkish population [8].

A general higher values in all linear dimensions for males as compared to females in a Nigerian population [17]. Similarly, the present study reported Sella Length as the only dimension that shows statistically significant difference. However, no statistical difference exist in other dimensions of the present study. This similar outcome could be described as a result of geographical proximity and comparable populace used in both studies. On the other hand, no significant difference between sella turcica of male and female subjects was demonstrated but nevertheless, a slight difference between the sella dimensions of males and females was observed in the study [18]. The trivial contrary finding may be due to geographical differences, racial or ethnic factors.

Although, the present study revealed a similar outcome of males subjects having considerably higher values for Sella Length and Sella Antero-posterior diameter than females whereas females have higher values for Sella Depth with another study conducted in African populations [18]. This could also be explained as a proximity factor of subjects included in the study.

An earlier study revealed that pituitary fossa increased in size with age [28]. Longitudinal studies of sella turcica have illustrated positive results of age related increase in size, mainly because of its contents, i.e. the pituitary gland [29]. The present study revealed a significant difference in all the sella dimensions with the exception of Antero-posterior Diameter. The post-hoc analysis on Sella Width showed statistically significant difference between the first (18-25) age category and the fifth (56-65) age category.

A steady increase in size for both genders is expected during growth [26]. A cross-sectional study of orthodontic patients, revealed an increase in sella dimensions with age, mainly the 6 – 10 to the 21 – 25 age category [30]. In the study conducted in Iraq [21], the only significant difference was noted in Sella Depth. Higher values were reported for higher age group and lower values for lower age group in Sella turcica linear dimensions [31]. Similarly, a positive correlation was described of Sella Depth and Antero-posterior Diameter with age [22]. The age group of the patients is a determinant of the sella turcica dimensions [17]. Significant difference across age groups with Sella turcica linear dimensions was reported [7]. Also, a significant increase in some Sella turcica linear dimensions was noted with age, namely; Sella Length, Sella Width, Sella Height Median and Sella Height Posterior [8]. Furthermore, the present study revealed findings that shows agreement with most other studies. Although, most literature have limited number of dimensions to Sella Length, Sella Width and Sella Antero-posterior Diameter.

Different methods have been adopted by researchers to make an estimate of Sella area, such as simple methods of product of length and depth or planimetry to more complex methods of tracing the outline of the sella from the X-ray film or digital image [27]. The present study adopted the method

of multiplying the length by the depth and an estimated mean Sella Area of 87.1±24.8mm^2 was obtained. The mean value reported for male was 87.53mm^2 and for female was 86.4mm^2 with no statistically significant difference recorded in the present study.

Silverman's extensive study on Sella turcica, reported that gradual increase with age of Sella Area is expected which could be attributed to the function of the anterior lobe of the pituitary gland [24]. However, this is contradictory to the present study, as no statistically significant difference is recorded. These conflicting findings can be explained possibly by differences in approach and methodology used by different researchers. As the present study involved only adult subjects between the ages of 18 and 75. Whereas Silverman included much younger subjects. Nevertheless, trivial larger values was seen in older age groups as compared to younger age groups in the present study.

No significant difference in the mean values of males and females was found in an Indian populace [27]. Likewise, no sexual dimorphism or statistically significant difference for area estimations of sella turcica within a Bangladesh population [23]. The findings of these studies are in agreement with the present study.

A CT study of Sella Area was reported as 41.21mm^2 [19]. Dried sphenoid bones were studied and reported a value of 70 mm^2[32]. Similarly, a 3D CT study on Sella turcica was done and reported a value of 65.29 mm^2 [7], another study reported a value of 54.9mm^2 [23]. Sella turcica was evaluated in a Turkish population and reported a value of 69.15mm^2 and noted the only statistically significant difference in the Sella Area was among age groups [8]. However, the present study found no significant correlation between Sella Area and Age. The values reported by [32, 7, 8] are relatively similar to value reported in the present study as compared to [19, 23].

CONCLUSION

This present study has highlighted values for sella turcica linear dimensions for a Nigerian metropolitan population. Revealing the typical Sella Length sexual dimorphism in this population as seen in other populations of earlier studies. Also, significant differences are seen within the age categories in the Sella turcica linear dimensions with the exception of Sella Antero-posterior diameter. The Sella Area showed no sexual dimorphism or significant correlation with age in the studied population. The study further affirms the potentials of using CT scan images in surveying and describing the Sella turcica.

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