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Ocular Biometry Using Computed Tomography: In Jos, North Central Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author AJS participated in designing the study protocol, collecting data, manuscript preparation and final review. Author GT was involved in data collection. Author SMD participated in study protocol and final review of manuscript. Author OAA participated in the preparation and review of manuscript. Author AAS was involved in data analysis and review of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims and Objective: To determine the normal ocular dimensions (AP and width) in Jos, North Central Nigeria using computed tomography scan.
Subjects and Methods: The ocular images of 251 patients who had cranial CT in Jos University Teaching Hospital without obvious ocular anomaly were retrogressively studied. The antero-posterior (axial length) and width were obtained at the maximum mid-axial images showing the maximum size of the lens. Statistical information and analysis was performed using SPSS version 20. Pearson correlation was performed and the level of significance set at p=0.05 student t-test was also performed to compare the difference of the mean ocular dimensions and sexes.
Results: The mean axial length found was 24.61 mm (right) and 24.01 mm (Left) while the width was 24.31 mm (Right) and 23.21 mm (Left). The ocular biometry was slightly higher in the right eyeball than the left, and also in males than females (37.2±21.1 and 36.6±23.2 for the male and females respectively). All the axial lengths were higher than the width in both males and females.

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Conclusion: The ocular biometry were noted to be higher in males compared to females. The dimensions were noted to increase with age, though not statistically significant. The axial length was higher than the width.

Keywords: Ocular; biometry; computed tomography.

1. INTRODUCTION

The eye is the organ of vision that is housed in an orbit. It serves as a gateway for light appreciation, because it is connected to the brain by the optic nerve. Each eyeball is a cystic structure kept distended by the pressure inside it. Although, generally referred to as a globe, the eyeball is not a sphere but an ablate spheroid. The central point on the maximal convexities of the anterior and posterior curvatures of the eyeball is called the anterior and posterior pole, respectively. The equator of the eyeball lies at the mid plane between the two poles [1]. Normal values of ocular biometric studies acquired through CT-scan is affected by ethical issues related to radiation dose. Such studies were on CT scans performed for other reasons. Coupled with the cost of studies, there is scanty information on CT acquired ocular biometry especially in Africa [2].

Variation of its size can cause visual abnormalities such as myopia and hypermetropia. Ocular biometric values are useful in the diagnosis of macro and micro-ophthalmia and aids explanation of the relationship between ocular size and variation in refractive index [3,4].

There have been several studies to measure the axial length of the living human eyes in the past. Some of these studies utilized various techniques which includes the indirect radiographic, ultrasonographic and photographic methods [5-8]. However, modern advanced radiologic imaging modalities such as multi detector CT and MRI can assess the eyeball and its related ocular diseases and makes the clinical implications of such findings easily possible [8-10]. Ultrasound is commonly used in interrogating the eye, but it is operator dependent. MRI provides excellent anatomical detail compared to CT but has limitations in assessing calcification in the eye and motional artifact because of the duration needed to acquire images. It is more costly and not readily available.

CT biometry has some advantages which include the fact that it is painless, non-invasive and less time consuming. It is performed on outpatient basis with high accuracy rate and does not require strict patient positioning. It also detects abnormal ocular anatomy and there is absent magnification error [11].

Despite all these advantages, its routine use in ocular biometry is limited by radiation dose and cost.

2. MATERIALS AND METHODS

The study consisted of CT-scans taken from stored images on a 4-slice Helical BRIGHT SPEED GE CT machine. Which were performed in axial sections at 2.5 mm slice thickness and a window level of 50 Hounsfield unit. All scans recorded for this study were those considered by the researchers to be of normal eyeballs without any observable intra ocular disease and whose medical records are devoid of ocular abnormality.

The medical records of two hundred and seventy (270) patients who had cranial CT Scans performed in Jos University Teaching Hospital (JUTH) from January to December 2014 were retrospectively examined. We obtained permission from the ethical committee of the institution on the use of data for the study. About 19 (7%) of the patients records were excluded from this study based on the exclusion criteria viz: positive ophthalmic pathology or lesions such as tumors and fractures images that are not clear such as due to motion blur, images that show deformity or irregularities of the eyeball contour and those with > 3 mm difference between the values obtained by the researchers.

Consequently, 251 consecutive patients' cranial CT examinations were recruited into the study.

The stored images of the eyeball were magnified four time during their review to reduce measurement errors. The slices chosen for ocular measurements were mid-ocular slices showing the maximum axial size of the eyeball and which showed the maximum size of the lens.

Ocular dimensions were obtained in axial length (antero-posterior diameter) of the eyeball and in width (transverse diameter). The antero-posterior diameter is the distance through the visual axis from the anterior corneal surface to the posterior wall of the choroid in axial view and it included the anterior chamber length, lens thickness and the vitreous chamber length. The width or transverse diameter is the maximum transverse diameter between the temporal and nasal ends of the eye in axial view.

Statistical information and analysis was performed using SPSS version 20. For each eye, the axial length was designated "AP" and the transverse length as "width" as sean in Fig. 1. The average value of the AP and Trans was calculated for each eye and designated "AV RT and AV LT" for the right and left eye respectively. An average of all the dimensions in each individual was calculated and designated "Both eyes". Pearson correlation was performed and the level of significance set at d=0.05 student t-test was also performed to compare the difference of the mean ocular dimensions and sexes.

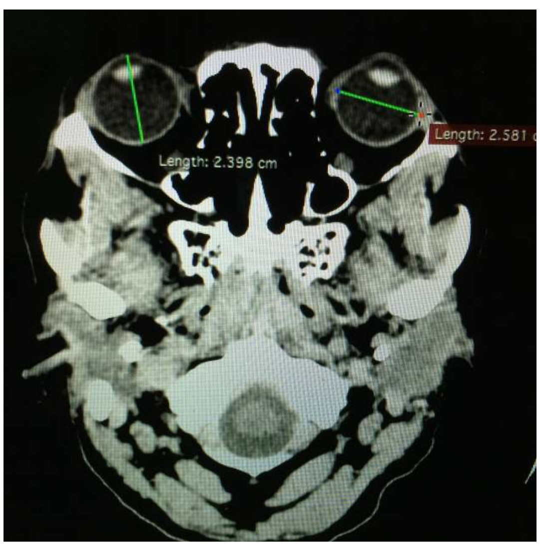

Fig. 1. Axial CT scan showing measurement of length and width of the eye

Refractive errors of the people involved in this study was not evaluated. This is the limitation of this study.

3. RESULTS

A total of 251 patients made up of 175 males (69.7%) and 76 (30.3%) females were studied. The difference in the mean age of the sexes was not statically significant. The minimum age was six month and the oldest in the study was ninety years (Table 1).

There was slightly larger mean ocular dimensions in males than females though not statistically significant. The AP and width are higher in the right eye compared to the left. The AP was noted to be higher than the width in both sexes (Table 2).

Ocular dimensions were consistently smaller in children less than 10 years of age than in adults. Also, the ocular dimensions with age was noted to be higher in the age groups of 21-30 and 31-40 years of age. There was a drop in the observed dimensions among 41-50 years (Table 3).

Again, the mean ocular dimension of the right eye is slightly greater than that of the left eye with increasing age. Also the mean ocular dimensions were greater in males compared to females with increasing age. The increase in ocular dimensions with age correlated significantly (Table 4).

4. DISCUSSION

The knowledge of the ocular normogram in an environment is important evaluating patients that present with disease condition of the eyes. The eye is the organ of sight and its variation in size can cause visual abnormalities such as myopia and hypermetropia. Ocular biometric values are useful in the diagnosis of macro and micro-ophthalmia and aids explanation of the relationship between ocular size and variation in refractive index [3].

From the results obtained, the mean antero-posterior diameter and width for the right eye was 24.91 mm and 24.41 mm and left eye 24.31 mm and 23.61 mm for males; and 24.31 mm and 23.61 mm for the right eye and 24.31 mm and 22.81 mm for left eye for the females respectively. Hence, the axial length was higher than the width. The antero-posterior (axial) length value is similar to that obtained else where; in India 24.5 mm [11], mongolians 23.13 mm [12], caucasians children 23.49 mm [13]. Therefore, racial differences does not play any significant role in evaluating dimension. However, similar study in Nigeria (Benin) shows that the width was longer than the axial length which vary significantly with the findings here [3].

No reason could be adduced for these difference. It could also be due to none localization of the exact center of the globe.

Ocular dimensions (AP and width) increase with advancing age, however, 80% of adult eye size was achieved by age 4. Hahn et al documented rapid growth of the eyeball during the first 24 months of age, peaks between 18 and 30 years after which reduction was observed [14]. In this study however, similar observations was made, but the onset of reduction of ocular dimensions occurred later (from age 41 yrs) and peaked at age 61 yrs and above. Two peaks of increase in ocular dimensions was noticed in ages between 21-30 years and 31-40 years which was not observed in the study by Hahn et al. In the adult, axial length remains practically unaltered. A slight but steady change towards hyperopia is the rule, especially after the age of 40. The human eye grows extensively after birth. The full term newborn eye has a mean axial length of 16-18 mm. The mean adult values for axial length are 22-25 mm [15]. This is similar to our findings.

Table 1. Age distribution of study subject according to gender

Gender	N	Mean±SD	t	p	Min.	Max.
Male	175	37.2±21.1	0.188	0.851	0.5	80
Female	76	36.6±23.2			0.5	90
Total	251	37.0±21.7			0.5	90

Table 2. Mean values of globe diameter with respect to gender

Parameter	Gender		t	P
	Male	Female		
Rt AP	24.9±1.5	24.3±1.6	3.534	0.001
Lt AP	24.3±1.4	23.4±1.4	4.613	0.001
Rt width	24.4±1.3	23.6±1.3	4.923	0.001
Lt width	23.6±1.6	22.8±1.3	3.902	0.001

Table 3. Mean, age and sex distribution of globe diameter

Age	Sex	Fr	Rt AP	Rt width	Lt AP	Lt with
≤10	M	20	23.41.8	22.91.5	22.51.6	22.21.7
	F	14	22.21.7	22.01.4	21.41.4	21.41.1
	T	34	22.91.8	22.61.5	22.11.6	21.91.5
11-20	M	19	24.61.2	24.11.3	23.81.2	23.41.4
	F	10	24.41.2	23.80.6	23.50.5	22.80.6
	T	29	24.51.2	23.91.1	23.71.1	23.21.2
21-30	M	41	25.51.0	24.90.9	24.90.9	23.91.1
	F	5	25.51.1	24.61.1	24.60.9	23.81.1
	T	46	25.51.0	24.80.9	24.90.9	23.91.1
31-40	M	31	25.61.1	25.01.1	24.91.0	24.41.1
	F	10	25.01.2	24.31.1	24.31.1	23.50.9
	T	41	25.51.1	24.81.1	24.81.0	24.21.1
41-50	M	11	24.71.3	24.31.0	24.30.9	23.51.4
	F	16	24.41.1	23.61.1	24.41.1	22.91.2
	T	27	24.51.2	34.91.1	24.51.2	23.21.3
51-60	M	26	25.11.4	24.71.3	24.51.2	23.81.4
	F	11	25.01.0	24.20.9	23.91.1	23.60.9
	T	37	25.11.3	24.51.2	24.41.2	23.71.3
>60	M	27	24.91.4	24.31.2	23.91.7	23.32.2
	F	10	24.61.4	23.51.1	23.60.9	22.71.3
	T	37	24.81.4	24.11.2	23.91.6	23.12.0
Total	M	175	24.91.5	24.41.3	24.31.4	23.61.6
	F	76	24.31.6	23.61.3	24.31.6	22.81.3
	T	251	24.81.5	24.21.4	24.81.5	23.41.5

Table 4. Correlation between age (in years) and globe diameter (in mm)

Globe diameter (in mm)	Correlation coefficient (r)	P
Right AP	0.277	0.001
Left AP	0.254	0.001
Right width	0.246	0.001
Left width	0.171	0.007

Correlation is significant at the 0.01 level

In another study, the axial length was found to increase rapidly until age $10^1/_2$ years and this slowly increase without observing any decrease in two ocular dimension [16].

Although not statistically significant, right globe measurement were higher than the left. It was also noted that the right globe measurement was higher than that of the left in the studies in Nigeria by Ogbeide et al. [17] and elsewhere [17-19].

It was noted that the AP dimension and width in males was higher than that of females, which is statistically significant. Similar findings was noted in the study done by Ogbeide et al. [17] in Benin on ocular biometry using ultrasound. The factor that may attributed to this may be from human sexual dimorphism in which the male body habitus (and possibly organs) is generally bigger than that of the females [3].

The radiation associated with CT and the cost of the investigation has made usage for routine biometry an ethical dilemma [3]. Other imaging modalities that can be used in ocular biometry are ultrasonography and magnetic resonance imaging. Ultrasound is operator dependent and MRI is not readily available and very expensive.

5. CONCLUSION

The ocular dimension increased with age. The antero-posterior dimensions were higher than the width in both sexes. The dimensions in males were higher than that of females. Financial cost, increases irradiation and other factors make the use of computed tomography unlikely in the routine measurement of the eyeball diameters.

CONSENT

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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