



COMPUTED TOMOGRAPHY (CT) MEASUREMENT OF OCULAR DIMENSIONS AT BPKIHS

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ABSTRACT

Background & objectives: In country like Nepal, CT scans are more readily available than MRI. No such studies have been carried out in our part of the world on CT and there is need to have local data. Almost no study is available correlating the ocular diameter taken in all three dimensions and correlating it with the age and body mass index (BMI) of the patients till date. This study has been planned with objective to measure the maximum anterior-posterior (AP), transverse (TD) & cranio-caudal (CC) diameter of the eyeballs, to compare the obtained data on right and left side and in male and female and to correlate the ocular dimension with age and BMI. **Materials & Methods:** This was prospective study on CT para-nasal sinuses (PNS) over 6 month duration done in the Department of Radiodiagnosis and Imaging starting from January 26, 2022, after ethical clearance. The collected data were entered in the MS excel 2013 and converted into SPSS 11.5. For descriptive statistics frequency, percentage, Mean & SD were used. Analytical tests were independent samples t-test, paired sample t-test & Pearson's correlation. **Results:** Prospective 115 patients, 67(58.26 %) were Male & 48 (41.74 %) female. Maximum mean AP, transverse & CC diameters of both globes was 23.85 ± 1.8 mm (mean $\pm$ SD) & 23.81 ± 1.93 mm respectively; 23.93 ± 1.94 mm and 24.06 ± 2.06 mm respectively; 24.3 ± 2.08 (mm) & 24.1 ± 2.14 (mm) respectively & showed negative correlation in all 3 dimensions with the age of the patients & BMI. **Conclusions:** As pioneer study, it provided reference ranges of ocular diameter in all 3 dimensions on CT & it is first study which used all the three dimensions of ocular measurements correlating with age & BMI.

KEYWORDS: Diameters, comparison, correlation.

INTRODUCTION & OBJECTIVES

Most of the ocular conditions such as congenital glaucoma, trauma to the eyeball, retinoblastoma and other malignancy are capable of changing the size of the eyeball.^[1] Some studies^[2] are conducted on ocular axial length measurement among normal adults using Magnetic Resonance Imaging, the normal ranges for ocular measurements were suggested as (mean $\pm$ SD): AL of the right globe, 23.32 ± 1.34 mm (range 22.0–24.7) and AL of the left globe, 23.29 ± 1.22 mm (range 22.10–24.51).

Some literature^[3] suggested that the average axial length was 23.09 mm ranging from 18.13 mm to 29.09 mm using ultrasonography. As per Annongu IT et al⁴ (2018) on 111 patients with aim to establish computer tomography (CT) scan, the mean $\pm$ 2 SD) ocular sizes in anterior-posterior(AP) and transverse diameter(TD) for both eyes were $22.1\text{mm} \pm 1.88\text{mm}$ and $22.9\text{mm} \pm 1.20$ mm respectively in their study.

Computerized tomography (CT) scan uses ionizing radiation and can generate excellent hard tissue imaging contrast with moderately good soft tissue resolution. CT scan has a number of advantages like lower cost, ready accessibility, scan speed, etc. which provide a relatively reliable imaging modality for most patients. In country like Nepal, CT scans are more readily available than MRI. Almost negligible study is available on the correlation of the ocular dimension with age and BMI. Most study have been done regarding normative data on the ocular dimension in the other part of the world, but to the best of available knowledge, there is no study that has been carried out in this area and there is need to have local data, hence this study has been planned.

Most studies are conducted on the dimension of eye ball but only few studies are conducted on CT on the correlation of the ocular dimension with age and comparison with the gender. Only one or two studies have been reported that also taken the variation of the eye ball size considering BMI. The obtained data will

also serve great helpful in ophthalmological, oculoplastic and neurological practice. Hence, this study was conducted with aims & objectives to measure the maximum anterior-posterior, transverse & cranio-caudal diameter of the eyeballs, to compare the obtained data on right and left side and in male and female and to correlate the ocular dimension with age and BMI.

MATERIAL & METHODS

This study was a hospital based prospective study carried out over a period of six months starting from January 2022 after ethical clearance of the protocol from Institutional Review Committee (IRC) in the department of Radiodiagnosis and Imaging at B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal. All the patients referred for CT of the paranasal sinuses (PNS) at BPKIHS were included in the study. Patients with orbital/ocular disorder, individuals in whom orbital/ocular abnormality detected on the CT scan, individuals with asymmetric scans or scans with artefacts for any reason that may cause errors in the ocular measurements and the patients not giving consent for the participation in the study were excluded. The patient's identities were kept confidential.

After taking informed consent, collection of data in a structured proforma from patient record file such as age, gender, height, Body Mass Index (BMI) and brief, relevant clinical details were recorded. Collection of such information from the patient or their relatives was done if any relevant information were missing in the patient's record file. Measurement of the height and weight for the calculation of the BMI of the patient were also done in those cases where it was not provided.

NCCT or NCCT followed by CECT of the PNS were done with initial few cases on the Neusoft 16 slice CT machine and remaining all the cases on the GE revolution 256 slice CT scan machine. Volumetric scan

were obtained in which multiplanar reconstructions (MPR) were done and the measurements as per structured proforma were taken and recorded. Maximum antero-posterior (AP) and maximum transverse diameter (TD) of both the globes were measured at the level of mid-ocular axial slices. Maximum cranio-caudal (CC) diameter of the globe was taken at mid-equator level. Single point of reference was taken for a particular measurement to avoid the possibility of the measurement bias.

The data were entered in the MS excel 2013 and converted into SPSS 11.5 for statistical analysis. For descriptive statistics, frequency, percentage, Mean and SD were used along with graphical and tabular presentation. Analyses tests used in this study were independent samples t-test, paired sample t-test, and Pearson's correlation. A p-value <0.05 were considered statistically significant.

RESULTS

Total of 123 patients were enrolled in the study, 8 were excluded as per our exclusion criteria. So, data analysis was done on the 115 patients (n=115). Out of 115 patients 67(58.26 %) were Male and 48 (41.74 %) were female. Mean age of the patients in our study were 38.9 years ranging from 13 to 84 years. The maximum numbers of the patients were between 30-39 years which included 41 (35.65 %) patients. 15 patients were between 40-49 years of age, 50 to 59 and 60 to 69 years included 12 patients each and the least number of patients were above 70 years which included only 4 (3.33 %) patients in our study.

Majority of the patients belonged to Sunsari 31 (26.95 %) followed by Morang 20 (17.39 %), Jhapa 18 (15.65 %), Saptari 17 (14.78 %), Siraha 11 (9.56 %), Dhankuta 8 (6.95 %), Sankhuwasabha 4 (3.48 %), Janakpur 4 (3.48 %) and from India 2 (1.74 %) (Figure 1).

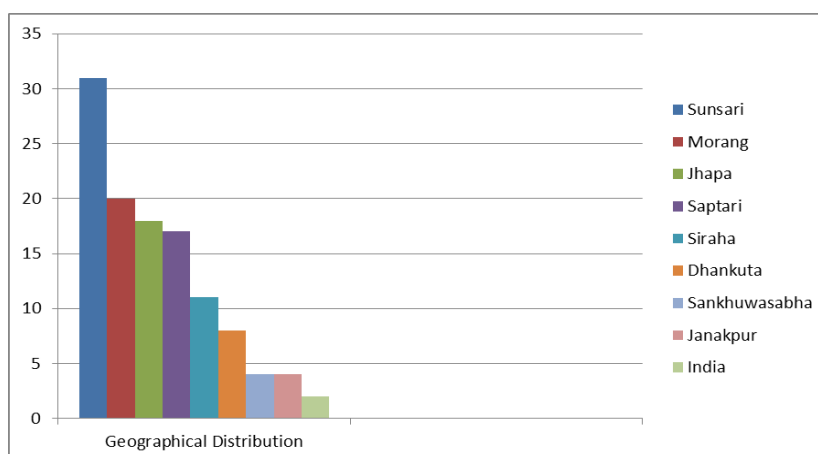


Figure 1: Showing Geographical Distribution of the patients.

Maximum mean anterior-posterior (AP) diameter of right globe was 23.85 ± 1.8 mm (mean $\pm$ SD) and left globe 23.81 ± 1.93 mm, maximum mean transverse diameter of

right globe was 23.93 ± 1.94 mm and left globe 24.06 ± 2.06 mm, maximum Cranio-caudal (CC) diameter of the right globe was 24.3 ± 2.08 (mm) and left globe was

24.1 $\pm$ 2.14 (mm). Paired 't' test was applied and the difference between the values of both eyes were statistically insignificant, summarized in Table (1).

Table 1: Mean ocular dimensions and comparison of the data obtained on right and left side.

Dimensions	Right Globe	Left Globe	P value
Maximum Antero-posterior (AP) diameter (mm)	23.85 $\pm$ 1.8	23.81 $\pm$ 1.93	0.8663 (Insignificant)
Maximum transverse diameter (mm)	23.93 $\pm$ 1.94	24.06 $\pm$ 2.06	0.6227 (Insignificant)
Maximum Cranio-caudal (CC) diameter (mm)	24.3 $\pm$ 2.08	24.1 $\pm$ 2.14	0.4731 (Insignificant)

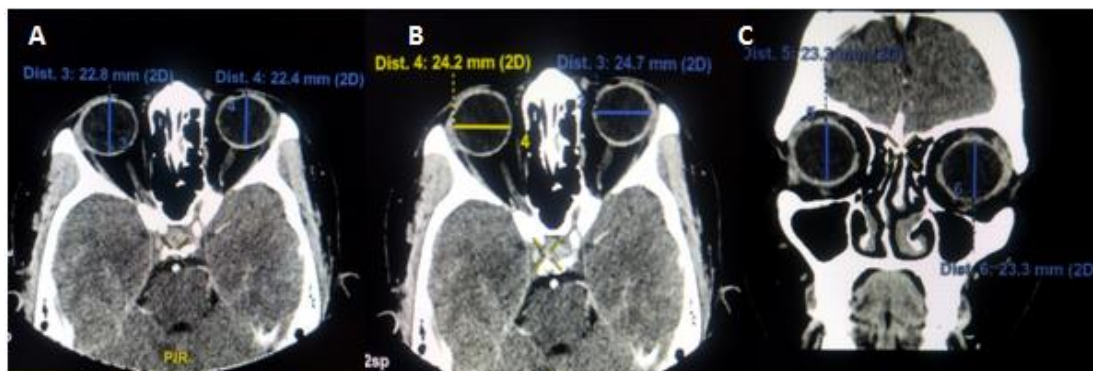


Figure 2: Showing a case of 29-year-old female who presented with the H/O headache and sneezing. CECT PNS revealed no obvious pathology. Her maximum antero-posterior (AP) & transverse diameter (TD) measurement of globe was taken at mid-ocular axial slices (A, B) and maximum cranio-caudal (CC) diameter was measured at mid-equator level (C).

Mean BMI with standard deviation of individual age groups were calculated (Table 2).

Table 2: Mean BMI as per age groups

Age groups (Years)	Mean BMI (Kg/m ²)
≤ 19 (n=8)	20.65 $\pm$ 0.48
20-29 (n=23)	19.7 $\pm$ 2.37
30-39 (n=41)	22.94 $\pm$ 2.81
40-49 (n=15)	24.9 $\pm$ 1.82
50-59 (n=12)	23.53 $\pm$ 0.29
60-69 (n=12)	24.1 $\pm$ 1.22
≥ 70 (n=4)	23.75 $\pm$ 0.25

Maximum mean anterior-posterior (AP) diameter of right globe and left globe, maximum mean transverse diameter of right globe and left globe and maximum Cranio-caudal (CC) diameter of the right globe and left globe was calculated for both the males and the females. Paired 't' test was applied and the difference between the values of both eyes were statistically insignificant (≥ 0.05) in both the genders, summarised in Table (3).

Table 3: Comparison of Ocular diameter with Gender.

Comparison of Ocular diameter with Gender									
	Right Globe AP (mean $\pm$ SD) mm	Left Globe AP (mean $\pm$ SD) mm	p value	Right Globe transverse (mean $\pm$ SD) mm	Left Globe transverse (mean $\pm$ SD) mm	p value	Right Globe CC (mean $\pm$ SD) mm	Left Globe CC (mean $\pm$ SD) mm	p value
Male	23.36 $\pm$ 1.72	23.29 $\pm$ 1.99	0.978	23.74 $\pm$ 1.82	23.68 $\pm$ 1.93	0.982	23.98 $\pm$ 1.51	23.76 $\pm$ 1.83	0.926
Female	24.56 $\pm$ 1.66	24.56 $\pm$ 1.64	0.979	24.21 $\pm$ 2.06	24.63 $\pm$ 2.09	0.89	24.76 $\pm$ 2.43	24.71 $\pm$ 2.35	0.99

Correlation of the ocular diameter for all 3 dimensions (AP, transverse and CC) of both the eyes were done with the age of the patients. Pearson's correlation was applied and P value ≤ 0.05 was taken statistically significant. Diameters of the both globes showed negative correlation in all 3 dimensions with the age of the

patients which was statistically significant for both globes AP diameter, right globe transverse diameter and both globes cranio-caudal diameters. Value for left globe transverse diameter was statistically insignificant, summarised in Table (4).

Table 4: Correlation of ocular dimensions with Age
Correlation of ocular dimensions with Age.

Parameters	Coefficient of correlation (r)	P value
Right Globe AP	-0.243	0.0089*
Left Globe AP	-0.198	0.0338*
Right Globe transverse	-0.251	0.0068*
Left Globe transverse	-0.178	0.058
Right Globe CC	-0.248	0.0075*
Left Globe CC	-0.249	0.0073*

(* denotes statistically significant P value)

Correlation of the ocular diameter for all 3 dimensions (AP, transverse and CC) of both the eyes were done with the BMI of the patients. Pearson's correlation was applied and P value ≤ 0.05 was taken statistically significant. Diameter of the both globes showed negative correlation in all 3 dimensions with the BMI of the patients which was statistically in-significant for both globes except for right globe transverse diameter and right globe cranio-caudal diameters which shows statistically significant correlation, summarised in Table (5).

Table 5: Correlation of ocular dimensions with BMI.

Correlation of ocular dimensions with BMI		
Parameters	Coefficient of correlation (r)	P value
Right Globe AP	-0.165	0.0785
Left Globe AP	-0.105	0.264
Right Globe transverse	-0.242	0.0091*
Left Globe transverse	-0.154	0.1006
Right Globe CC	-0.231	0.013*
Left Globe CC	-0.167	0.075

(* denotes statistically significant P value)

DISCUSSION

Our study is the first study conducted in the Eastern Nepal with aim to provide the reference standard of the ocular diameter on computed tomography in all three dimensions. It is pioneer study in the South Asian continent that worked on the correlation of the ocular dimensions with the age and body mass index (BMI).

As per the prospective study conducted by **Bekerman I et al¹ (2014)** on 250 patients on variations in eyeball diameters of the healthy adults, the size of a human adult eye was approximately 24.2 mm (transverse) $\times$ 23.7 mm (sagittal) $\times$ 22.0–24.8 mm (axial). The left eyeball was slightly larger than the right but not statistically significant (**P=0.17**) difference were obtained on the comparison of the diameters of the eyeballs on the right and the left side. The ranges of ocular measurements provided by **Aiyekomogbon JO et al² (2017)** were (mean $\pm$ SD): AL of the right globe, 23.32 $\pm$ 1.34 mm (range 22.0–24.7) and AL of the left globe, 23.29 $\pm$ 1.22 mm (range 22.10–24.51). The length of the IZL was 103 $\pm$ 4.78 mm (range 98.2–107.78). The study population involved adult individuals 18–80 years in their study.

All measurements in male patients were significantly higher than those in female patients (**P < 0.001**) in their study. **Albashir SI et al³ (2015)** study showed that the average axial length was 23.09 mm ranging from 18.13 mm to 29.09 mm. It was longer in males (average 23.29), ranging from 20.31 mm to 28.48 mm and shorter in females (average 22.81). In **Annongu IT et al⁴ (2018)** study, a total of one hundred and eleven images were analyzed which comprised of 79 (71.2%) males and 32 (28.8%) females. The mean age studied was 40 $\pm$ 1.79 years. Their study showed the mean $\pm$ 2 SD ocular sizes in anterior-posterior (AP) and transverse diameter (TD) for both eyes were 22.1mm $\pm$ 1.88mm and 22.9mm $\pm$ 1.20mm respectively in their study. The right eye was 21.9mm $\pm$ 2.33mm and 22.9mm $\pm$ 1.09mm and the left eye was 22.3mm $\pm$ 1.24mm and 23.0 $\pm$ 1.30 mm in both AP and TD respectively. The measurements were slightly higher on the left. The mean ocular measurements were higher in males and were statistically significant in the transverse measurements on both sides (**P<0.04**). Established ocular sizes on CT therefore showed that males had slightly larger eyeballs in comparison to females and there was some reduction of ocular sizes with age as per there study.

In our study of 115 patients, 67(58.26 %) were Male and 48 (41.74 %) were female. Age ranges of the participants were 13 Years to 84 years, with a mean of 38.9 years which is almost consistent with the mean age of the study conducted by **Annongu IT et al⁴ (2018)**. Similar to this study, male outnumber the female in our study. In their study, maximum numbers of the patients are in 41–50 years of age group, however in our study population, maximum number of cases is between 30–39 years of age group.

Maximum mean anterior-posterior (AP) diameter of right globe was 23.85 $\pm$ 1.8 mm (mean $\pm$ SD) and left globe 23.81 $\pm$ 1.93 mm, maximum mean transverse diameter of right globe was 23.93 $\pm$ 1.94 mm and left globe 24.06 $\pm$ 2.06 mm, maximum Cranio-caudal (CC) diameter of the right globe was 24.3 $\pm$ 2.08 (mm) and left globe was 24.1 $\pm$ 2.14 (mm) in our study which is almost consistent with the study done by **Bekerman I et al¹ (2014)**, **Aiyekomogbon JO et al² (2017)**, **Albashir SI et al³ (2015)**. However, transverse diameter in our study was slightly higher than the transverse diameter obtained by the study conducted by **Annongu IT et al⁴ (2018)** of nearly similar sample size. This difference might be due to geographic or racial variation, as our study is the pioneer study in our population which sets a new reference standard for the transverse diameter of ocular diameter in our population on computed tomography. Our study showed our female population has slightly larger eye ball than the male, however, this difference is not statistically significant in our study. No statistically significant difference between the antero-posterior,

transverse and cranio-caudal diameter of the right and the left eye were obtained in our study.

In our study, correlation of the ocular diameter for all 3 dimensions (AP, transverse and CC) of both the eyes were done with the age of the patients. Pearson's correlation was applied and P value ≤ 0.05 was taken statistically significant. Diameters of the both globes showed negative correlation in all 3 dimensions with the age of the patients which is statistically significant for both globes AP diameter, right globe transverse diameter and both globes cranio-caudal diameters. Value for left globe transverse diameter was statistically insignificant. The findings obtained in our study are almost consistent to the findings obtained by **Bekerman I et al¹ (2014)** except for the transverse diameter of the orbit showed strong positive correlation ($r = 0.88$) in their study.

Correlation of the ocular diameter for all 3 dimensions (AP, transverse and CC) of both the eyes were done with the BMI of the patients in our study. Diameter of the both globes showed negative correlation in all 3 dimensions with the BMI of the patients which is statistically in-significant for both globes except for right globe transverse diameter and right globe cranio-caudal diameters which shows statistically significant correlation which is almost similar to the data obtained by **Roy A et al⁹ (2015)** on the correlation of the ocular dimensions with the body mass index (BMI).

CONCLUSION

Our study is the pioneer study conducted on the computed Tomography in measuring the ocular dimension in our population in all the three dimensions, comparing it with both the side and correlating it with age and BMI. Maximum mean anterior-posterior (AP) diameter of right globe was 23.85 ± 1.8 mm (mean $\pm$ SD) and left globe 23.81 ± 1.93 mm, maximum mean transverse diameter of right globe was 23.93 ± 1.94 mm and left globe 24.06 ± 2.06 mm, maximum Cranio-caudal (CC) diameter of the right globe was 24.3 ± 2.08 (mm) and left globe was 24.1 ± 2.14 (mm) in our study. Transverse diameter in our population was slightly higher than the nearly similar study done on the other populations of similar sample size. Our study is the first study showing female population has slightly larger eye ball than the male, however, this difference is not statistically significant. These findings might be due to geographical variation. Diameters of the both globes showed negative correlation in all 3 dimensions with the age of the patients & BMI in our study. As pioneer study done at our population, our study provided new reference ranges of ocular diameter in all the three dimensions on computed tomography in our population & it is the first study which used all the three dimensions of ocular measurements correlating with age & BMI.

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