Original Article

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Radiology Section

Normative Orbital Measurement Based on Computed Tomography Imaging in Tertiary Care Hospital, Bangalore, Karnataka

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ABSTRACT

Introduction: The orbit is an anatomically complex region. Clear idea of the normal orbital measurements is needed for the diagnosis and management of the various diseases that may affect the orbit like optic neuritis, optic nerve glioma, meningioma, proptosis and exophthalmos.

Aim: To evaluate normative orbital measurement at tertiary care hospital in Bangalore, Karnataka in Indian population based on Non Enhanced Computed Tomography (NECT) imaging.

Materials and Methods: A cross-sectional observational study of 100 patients referred to a tertiary care centre for NECT of the brain for diseases other than those of the orbits was conducted. Patients having any orbital disorder, surgery or trauma and having metallic implants were excluded from the study. The patients of all age groups and either sex were included. The horizontal orbital diameter, vertical orbital diameter, orbital index, optic nerve complex, globe position, interorbital diameter and interzygomatic line measurements were calculated for 100 patients, i.e., total of 200 orbits using both axial and direct coronal CT images. Mean measurements of these parameters were calculated. Scans were performed on Siemens Somatom Perspective 128 slice multi-detector CT scanner. All statistical analysis was performed using Statistical Package for The Social Sciences (SPSS) for windows software (SPSS Inc. Illinois, Chicago, USA).

Results: The mean orbital index was 118.6 and 118.3 for right and left orbit, respectively. It was derived from mean horizontal orbital diameter of 32.5 mm and 31.7 mm of right and left orbit, respectively and mean vertical orbital diameter of 38.4 mm and 37.4 mm of right and left orbit, respectively. Mean optic nerve sheath complex diameter was 5.2 mm and 5.4 mm for right and left orbit, respectively, while mean globe position measurements 6.7 mm and 6.8 mm of right and left orbit, respectively. Average interorbital distance was 22.9 mm and average interzygomatic distance 97.1 mm.

Conclusion: The present study has given normative mean measurements for various orbital structures that are essential to ophthalmologists and radiologists to differentiate normal from abnormal dimensions which is likely to be helpful in accurate assessment of various orbital pathologies.

Keywords: Globe position, Optic nerve, Orbital diameter, Orbital index

INTRODUCTION

The orbit is a structurally complex area. A better idea of the normal dimension of orbit plays key role in the diagnosis and management of the various orbital disease and pathology like optic neuritis, optic nerve glioma, meningioma, proptosis and exophthalmos. The present available data of normal orbital measurement are mainly from western countries [1]. Sheikh M et al., demonstrated normal orbital values in Middle Eastern population which was used in assessment of thyroid opthalmopathy [2]. Chatdokmaiprai C et al., demonstrated normal interorbital distance in Thai population [3]. Availability of such kind of data is lacking from Indian subcontinent. The purpose of this study was to evaluate normative orbital measurement at tertiary care hospital in Indian population based on NECT imaging. Orbital radiograph, ultrasound and MRI orbit also can be used for radiological assessment of normal orbital measurements.

MATERIALS AND METHODS

A cross-sectional observational study was done from October 2019 to March 2020 at teritary care center, Bangalore, Karnataka, India. A total of 100 patients came for NECT brain for diagnosis of disease except orbital pathology. Ethical committee approval was taken for conducting the study, and its number is RRMCH-IEC/57/2019-2020.

According to Yamane formula,sample size was calucutated that is:

n=N/(1+Ne*2)

Where,

n= sample size

N= known population size, which here is average number of patients visiting our Radiology Department for CT Brain (except trauma; orbital pathologies cases), which were 22 per month. Average was calculated by referring data of number of patients who visited in past one year (2019 to 2020) for CT Brain excluding trauma and orbital pathologies cases. And the study period was of 6 months, so N=22×6=132.

e=margin of error (for 95% confidence level, margin of error=0.05)

$n=132/1+132\times(0.05)^2$

n=132/1.33=99.248≈100.

Inclusion and Exclusion criteria: Patients with history of any orbital disorder, surgery or trauma and having metallic implants were excluded. Age group between 5 to 85 years and either sex subjects were included in this study.

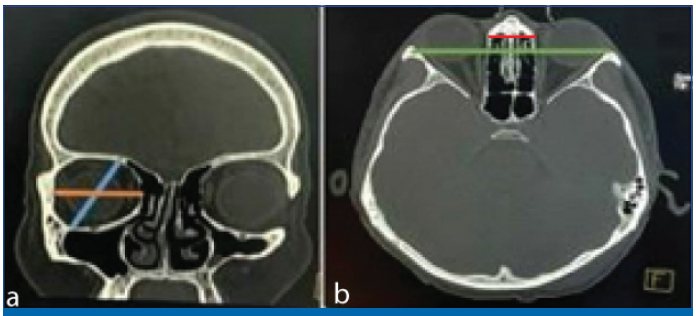
Procedure

Scans were performed on Siemens Somatom Perspective 128 slice multi-detector CT scanner. Bone and soft tissue windows were used according to the contemporary protocols [1]. Right and left orbital measurements were calculated differently. The horizontal and vertical diameters of the orbit were estimated by measuring widest distance between medial lateral and superior inferior orbital walls, respectively [Table/Fig-1a].

Orbital Index (OI) was calculated using the following formula:

$$OI=\frac{\text{Maximum vertical distance of the orbital cavity}}{\text{Maximum horizontal distance}}\times 100$$

Interorbital distance was measured on axial scan by estimating the minimum distance between medial orbital walls [Table/Fig-1b]. Interzygomatic distance estimated by measuring the maximum distance in-between the points on zygomatic arch's anterior part [Table/Fig-1b]. The optic nerve diameter (maximum) was measured with its sheath on coronal scans. (Optic nerve sheath complex diameter) [Table/Fig-2]. On axial scan in the mid globe, on slicing the distance between the posterior ocular surface and the interzygomatic line was used for estimating globe position [1].



[Table/Fig-1]: Coronal (a) and Axial (b) images in bone window showing measurement of orbital dimensions (blue and orange lines), Interorbital distance (red line) and interzygomatic distance (green line).

[Table/Fig-2]: Coronal image in soft tissue window showing measurement of optic nerve sheath diameter (red line).

STATISTICAL ANALYSIS

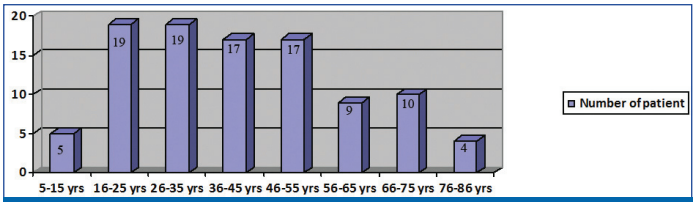
Statistical analysis performed using Statistical Package for The Social Sciences (SPSS) Version V27 for windows software (SPSS Inc. Illinois, Chicago, USA). The means of right and left sides and between the male and female samples were compared for significance using the student unpaired t-test. Confidence interval of 95% was assumed, and the differences were considered significant at <0.05.

RESULTS

Out of these 100 patients, majority were males (67%). The age ranged between 5 and 85 years with mean age in years 42±5 years. According to age wise distribution, 16-25 years and 26-35 years groups had maximum number of patients which was 19 in number, while 36-45 years and 46-55 years of groups had 17 patients each [Table/Fig-3].

In the overall population, mean orbital index was 118.6 and 118.3 for right and left orbit, respectively. It was derived from mean horizontal orbital diameter of 32.5 mm and 31.7 mm of right and left orbit respectively and mean vertical orbital diameter of 38.4 mm and 37.4 mm of right and left orbit, respectively [Table/Fig-4].

In females, optic nerve sheath complex diameter for right and left eye was 5.1 mm and 5.3 mm, respectively while in males, it was 5.2 mm and 5.4 mm, respectively [Table/Fig-5,6].



[Table/Fig-3]: Chart demonstrates number of patients according to the age.

Overall parameter		Right orbit	Left orbit	p-value
Horizontal orbital diameter	Mean (mm)	32.5	31.7	0.0278
	Minimum (mm)	24.8	23.5	
	Maximum (mm)	38.3	39.8	
	SD	2.24	2.83	
Vertical orbital diameter	Mean (mm)	38.4	37.4	0.0091
	Minimum (mm)	32.6	22.9	
	Maximum (mm)	45.6	43.4	
	SD	2.38	2.96	
Orbital index	Mean (mm)	118.6	118.3	0.8282
	Minimum (mm)	100.8	88.4	
	Maximum (mm)	160	159.5	
	SD	8.96	10.5	
Optic nerve complex	Mean (mm)	5.2	5.4	0.1589
	Minimum (mm)	2.9	3.1	
	Maximum (mm)	8.2	8.1	
	SD	1.0	1.0	
Globe position	Mean (mm)	6.9	7.1	0.5762
	Minimum (mm)	0.5	0.7	
	Maximum (mm)	12.8	13.7	
	SD	2.45	2.60	

[Table/Fig-4]: Shows mean (mm), minimum (mm) and maximum (mm) values of horizontal and vertical orbital diameter, orbital index, optic nerve complex and globe position in the overall population.
Student unpaired t-test was used; SD: Standard deviation; (<0.05, Statistically significant)

Parameter in female		Right orbit	Left orbit	p-value
Horizontal orbital diameter	Mean (mm)	37.4	36.3	0.6814
	Minimum (mm)	24.8	23.5	
	Maximum (mm)	34.3	36	
	SD	2.37	3.23	
Vertical orbital diameter	Mean (mm)	39.9	36.3	<0.0001
	Minimum (mm)	31.9	22.9	
	Maximum (mm)	41.2	41	
	SD	2.05	3.48	
Orbital index	Mean (mm)	120.2	119	0.6814
	Minimum (mm)	106.7	101.1	
	Maximum (mm)	160	159.5	
	SD	10.28	13.18	
Optic nerve complex	Mean (mm)	5.1	5.3	0.3958
	Minimum (mm)	3.4	3.1	
	Maximum (mm)	7.1	7.2	
	SD	0.93	0.97	
Globe position	Mean (mm)	7.3	7.7	0.5074
	Minimum (mm)	0.5	2.7	
	Maximum (mm)	12.8	11.4	
	SD	2.54	2.33	

[Table/Fig-5]: Shows mean (mm), Minimum (mm) and Maximum (mm) values of horizontal and vertical orbital diameter, orbital index, optic nerve complex and globe position in females.
Student unpaired t-test was used; SD: Standard deviation; (<0.05, Statistically significant)

In males, horizontal orbital diameter and vertical orbital diameter showed statistical significance for right and left eyes measurements.

Parameters in males		Right orbit	Left orbit	p-value
Horizontal orbital diameter	Mean (mm)	33.1	32.3	0.0353
	Minimum (mm)	27.8	25.9	
	Maximum (mm)	38.3	39.8	
	SD	1.89	2.43	
Vertical orbital diameter	Mean (mm)	39	38	0.0192
	Minimum (mm)	37.6	31.8	
	Maximum (mm)	45.6	43.4	
	SD	2.36	2.52	
Orbital index	Mean (mm)	117.8	117.9	0.9464
	Minimum (mm)	100.8	95.7	
	Maximum (mm)	140.7	143.9	
	SD	8.21	8.97	
Optic nerve complex	Mean (mm)	5.2	5.4	0.2700
	Minimum (mm)	2.9	3.2	
	Maximum (mm)	8.2	8.1	
	SD	1.04	1.05	
Globe position	Mean (mm)	6.7	6.8	0.8204
	Minimum (mm)	2	0.7	
	Maximum (mm)	12.3	13.7	
	SD	2.39	2.69	

[Table/Fig-6]: Shows mean (mm), Minimum (mm) and Maximum (mm) values of horizontal and vertical orbital diameter, orbital index, optic nerve complex and globe position in males.
Student unpaired t-test was used; SD: Standard deviation; (<0.05, Statistically significant)

The p-value was 0.0353 and 0.0192 of horizontal orbital diameter and vertical orbital diameter for right and left eye measurements in males respectively [Table/Fig-6]. The mean interorbital distance was 25.4 mm in females and 23.1 mm in males. The mean interzygomatic distance was 97.2 mm in females and 97.9 mm in males [Tables/Fig-7]. Horizontal orbital diameter of right and left eye of male and female shows the statistical significance (p-value <0.0001) [Table/Fig-8].

Parameters		Distance (in mm)	p-value
Average interorbital distance	Overall (SD)	22.9 (2.78)	0.0001
	Males (SD)	23.1 (2.76)	
	Females (SD)	25.4 (2.67)	
Average interzygomatic distance	Overall SD	97.1 (4.69)	0.4498
	Males (SD)	97.9 (4.22)	
	Females (SD)	97.2 (4.57)	

[Table/Fig-7]: Shows average interorbital distance and average interzygomatic distance in overall population, males and females.
Student unpaired t-test was used; (<0.05, Statistically significant)

DISCUSSION

Normative measurements act as a standard for evaluation of orbital disease. Based on race, ethnicity and religion, various previous study reports of normative measurements show slight variation and normative data based on imaging doesn't exist in our knowledge. Therefore, this study will be useful in providing such normative data in Indian population. Orbital dimensions are important in the preoperative planning for post-trauma reconstructive surgery [1].

Gupta V et al., study based on CT measurements had calculated the mean horizontal diameter 37.1 mm and 36.69 mm for right and left orbits, respectively. The vertical orbital diameter was 37.9 mm and 37.6 mm for right and left orbits, respectively. Orbital index of right and left orbit was 97 and 103, respectively [1].

Mekala D et al., had done study on south Indian dry skulls, in which they have found mean horizontal diameter of 41.7 mm for the right orbit and 41.8 mm for the left orbit. The vertical orbital diameter was 35.5 mm and 35.3 mm for right and left orbits, respectively. Orbital index of right and left orbit was 85.2 and 84.8, respectively [4].

Parameters	Male		Female		p-value
	Mean	SD	Mean	SD	
Right horizontal orbtal diameter	33.1	1.89	37.4	2.37	<0.0001
Left horizontal orbital diameter	32.3	2.43	36.3	3.23	<0.0001
Right vertical orbital diameter	39	2.36	39.9	2.05	0.0645
Left vertical orbital diameter	38	2.52	36.3	3.48	0.0064
Right orbital index	117.8	8.21	120.2	10.28	0.2098
Left orbital index	117.9	8.97	119	13.18	0.6244
Right optic nerve complex	5.2	1.04	5.1	0.93	0.3519
Left optic nerve complex	5.4	1.05	5.3	0.97	0.6473
Right globe postion	6.7	2.39	7.3	2.54	0.2504
Left globe postion	6.8	2.69	7.7	2.33	0.1039

[Table/Fig-8]: Shows mean (mm) and Standard Deviation (SD) values of horizontal and vertical orbital diameter, orbital index, optic nerve complex and globe position in males and females.
Student unpaired t-test was used

Dhanwate AD and Gaikwad MD, from Aurangabad had done study on the dry skull in Indian population. They found that in the male, mean horizontal diameter was 37.52 mm for the right orbit and 37.08 mm for the left orbit. The vertical orbital diameter was 32.64 mm and 32.39 mm for right and left orbits, respectively. Orbital index of right and left orbit was 87.28 and 87.66, respectively. In females, the mean vertical orbital diameter for right and left orbits were 32.55 and 32.31 mm, respectively. Mean horizontal diameter was 37.25 and 36.67 mm of right and left orbits respectively. Orbital index was 87.52 and 88.24 of right and left orbits, respectively [5].

As NECT for measurement of these orbital dimensions were used, therefore values in the present study are higher. It may be because of variation in genetics, race and methodologies. In Khademi Z and Bayat P, study based on Iranian population showed average vertical diameter was lesser and horizontal orbital diameter was higher in comparison with our study [6].

If optic nerve complex diameter is increased, it is an indirect indicator of elevated intracranial pressure. This measurement is useful in diagnosing glaucoma, Graves's orbitopathy, patency of ventriculoperitoneal shunt, traumatic brain injury or other causes of raised intracranial pressure. Average optic nerve diameter was 5.3 mm in this study which is comparatively higher than the Nugent RA et al., which showed 4.2 mm [7]. Lee JS et al., study showed 3.4 mm and Dubost C et al., study showed range between 4.3 and 4.8 mm [8,9].

The average interzygomatic distance was measured 97.9 and 97.2 mm in the males and females, respectively. It ranged from 81.2 mm to 107.5 mm in this study. While in Lee JS et al., study, the average interzygomatic distance was measured 103.8 mm and 101.5 mm in males and females respectively which was comparatively litter higher than our study [8].

Sound knowledge of normal interorbital distance is very much important. Increased interorbital distance signifies orbital hypertelorism which is a manifestation of craniofacial dysplasia. It is associated with craniosynostosis and holoprosencephaly. In this study, interorbital diameter was found to be 23.1 mm and 25.4 mm in the male and female, respectively and was higher in the female as compare to the male. It is statistically significant (p-value=0.0001).

In contrast to this study, Mafee MF et al., study on 400 patients based on NCCT shows mean interorbital diameter of 26.7 mm in the male and 25.6 mm in the female [10]. In an anthropometric analysis, among ethnic south Indian adults, the mean intercanthal distance was found to be 34.27±3.57 mm and 33.41±3.09 mm in the male and female, respectively [11]. We have also measured globe position in our study which is helpful to diagnose the exophthalmos.

Globe position, in the female was 7.3 mm and 7.7 mm in the right and left orbit respectively, while in the male it was 6.7 mm and 6.8 mm, respectively. Lee JS et al., study shows mean value of globe position 11.7 mm which is quite higher than our study [8]. It may be due to difference in ethnicity and genetics.

Orbital index for right and left eyes is 118.6 and 118.3 in present CT based study while it is comparatively less in the study of Kumar A and Nagar M, which is based on dry skull measurements and shows orbital index measurement 80.49 for the left eye and 79.65 for the right eye. They have classified the orbital index into the three categories. Orbital index if 89 or above megaseme, between 89 to 83 mesoseme and 83 or less microsome. According to this classification our study comes under the megaseme [12]

Another study based on the orbital dimension using dry skulls by Kaur J et al., shows mean right vertical diameter 31.9 mm and mean left vertical diameter 32.2 mm, which is lower than our study while, it shows mean right horizontal diameter 39.7 mm and mean left horizontal diameter 38.8 mm, which is higher than our study [13].

Jullabussapa N et al., study based on CT measurements of facial parameters shows mean interzygomatic distance of 99 mm in above 18 to 19 years age group which is almost equal to our study which is 97.1 mm. In our study, mean diameter of interzygomatic distance in the male and female is 97.9 and 97.2, respectively while it is 100.8 and 96.0 in the Jullabussapa N et al., study in above 18 to 19 years age group [14].

Limitation(s)

Small sample size and calculating orbital dimension on cross-sectional imaging, while it should be ideally calculated on dry skull bone specimens.

CONCLUSION(S)

NECT is a simple and effective way to measure the orbital measurements. In conclusion, we like to say that this study gives various normative orbital dimensions which are useful in diagnosis of various orbital diseases, in Indian population, by ophthalmologists, radiologists and neurosurgeons.

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