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Computed tomography measurement of orbital structures in a population of normal patients in a tertiary care hospital

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Abstract

Background: Our study aims to evaluate normal orbital structures with non-enhanced Computed tomography (NCCT) and determine the standard range for normative values of the orbital structure in Indian population.

Methods: Four hundred thirty-six normal orbits of 218 patients (135 men and 83 women) were retrospectively reviewed and evaluated in our department in this study. Clinical details of all patients were reviewed to ensure that they had no orbital diseases. Patients with any ocular, orbital or facial disorder or history of ocular, orbital or facial surgery were excluded from the study. Asymmetric scans, scan with artifacts due to dental material or eyeball implant were not included, also NCCT scans with abnormal orbital findings were excluded.

Results: The mean diameters of individual and sum of all extraocular muscles, the optic nerve-sheath complex, and the mean length of the interzygomatic line in male patients showed higher values than in female patients. However, there was no significant difference in orbital dimensions was found between male and female patients ($p>0.05$).

Conclusion: Our study has done an attempt to give normative mean measurements for different orbital structures that are essential to physicians, ophthalmologists, and radiologists for diagnosing and treating various orbital diseases.

Keywords:NCCT, Optic nerve, Orbital.

Introduction

The human orbit is a complex anatomical region. It is vital to have standard orbital dimensions, such as the diameter of the extraocular muscle (EOM), the optic nerve-sheath complex, and the position of the globe for diagnosing or differentiating orbital disease. Since the disorders of the EOM may alter their size, shape and density on non-enhanced Computed tomography (NCCT), prior sound knowledge of normative measurements may be a helpful diagnostic aid. The EOM may get enlarged in suspected orbital pathologies like thyroid ophthalmopathy, infections, neoplasms, metastases, and vascular malformations. The same knowledge of the position of the globe is essential for the diagnosis of exophthalmos. Likewise, the optic nerve sheath complex may also be enlarged in a multitude of pathologies, such as optic neuritis, optic nerve glioma, and meningioma. Interestingly, only a few reports on the normative values of the orbital structures have been published worldwide so far. However, data are not available from the eastern Indian population.

Our study aims to evaluate normal orbital structures with NCCT and determine the standard range for normative values of the orbital structure in said population.

Methods

Patients: Four hundred thirty-six normal orbits of 218 patients (135 men and 83 women) were retrospectively reviewed and evaluated in our department in this study. The age range of the patients was 11–80 years (mean age: 45 years). Clinical details of all patients were reviewed to ensure that they had no orbital diseases. Patients with any ocular, orbital or facial disorder or history of ocular, orbital or facial surgery were excluded from the study. Asymmetric scans, scan with artifacts due to dental material or eyeball implant were not included, also NCCT scans with abnormal orbital findings were excluded.

Methods: Both axial and direct coronal, 5-mm thick non-overlapping contiguous sections were obtained in all patients with a CT scanner (GE Optima 660 64 slice). The axial sections were acquired at an angle of 10–15 degrees to the orbito-meatal line and the coronal sections were acquired perpendicular to it. All scanning was performed at constant window level and width settings of 90 and 350 HU respectively. The interzygomatic line is a horizontal line drawn between the most anterior parts of the zygomatic bones in the axial plane. The interzygomatic line at the midglobe section was used as a reference line to determine the normal position of the globe in the NCCT. The globe position was determined by the perpendicular distance between the interzygomatic line and the posterior margin of the globe in the midglobe section of the axial scan (Figure 1). The width of the optic nerve sheath complex was measured perpendicular to its course at the thickest portion of the nerve on the axial CT section. Horizontal diameters of the lateral and medial rectal muscles were measured on the axial, whereas the superior muscle group and inferior rectus muscles on coronal CT section (Figure 2). The superior muscle group comprises of superior rectus and the levator palpebrae superioris muscle which were measured together as a single muscle group as they could not be evaluated separately on imaging.

Statistics: The paired samples t-test was used to compare data obtained from the right and left orbits. The independent samples t-test was used to compare data obtained from male and female patients. Ninety-five percent normal cut-off values were computed by adding and subtracting 2SD from the mean. All statistics in this study were done using SPSS-21 software.

Results

Mean values for the diameter of individual and sum of all extraocular muscles, the distance between the interzygomatic line and the posterior margin of the globe, the width of the optic nerve-sheath complex, the length of the interzygomatic line, and the difference in ranges between right and left orbit data are given in Table 1. No statistically significant difference was found between right and left orbit data ($p>0.05$). Mean values and normal ranges for muscle diameters and globe position were thereafter measured using only left orbital data. Mean width was 3.5 mm in medial rectus, 3.6 mm in lateral rectus, 4.2 mm in superior rectus-levator complex, and 3.9 mm in inferior rectus (Table 1). In male cases, the mean medial rectus width was 3.7 mm, 3.8 mm in lateral rectus, 4.1 mm in superior complex, and 4.0 mm in inferior rectus (Table 2). In women, the medial rectus muscle was 3.4 mm, lateral rectus was 3.4 mm, superior complex was 4.0 mm, and inferior rectus was 3.9 mm (Table 2). The mean diameters of individual and sum of all extraocular muscles, the optic nerve-sheath complex, and the mean length of the interzygomatic line in male patients showed higher values than in female patients. However, there was no significant difference in orbital dimensions was found between male and female patients ($p>0.05$).

In our study, the mean sum of all extraocular muscles was 14.9 mm, the optic nerve-sheath complex was 4.4 mm, the posterior globe position was 8.1 mm and the mean length of the interzygomatic line was 96 mm.

In regard to age, the mean diameter of the single extraocular muscles, the aggregate of all four muscles, the optic nerve-sheath complex diameter, and the mean length of the interzygomatic line tended to increase with age except that a decline has been noticed after fifth decade of age. (Table 3).

Discussion

The extraocular muscles are long, thin, well-defined anatomical structures that extend from the orbital apex to the globe. Their longitudinal section reveals a somewhat fusiform shape, while in the coronal section they are rectangular or oval on CT images. Measurement of extraocular muscle diameters in the axis perpendicular to the orbital wall is also used in CT imaging worldwide. Consequently, if the extraocular muscles are impaired by orbital or systemic disease, the size, shape and density on the CT images may alter, prior knowledge of normative measurements may be a valuable diagnostic aid. [1,2] It is necessary to determine the window level and width to obtain images of the extraocular muscles. Any adjustment in the window level and width settings results in different muscle size values. [3,4,5] Our normative data are reliable for a specific window level of 90 HU and width settings of 350 HU, emphasising that window settings should be the same for a precise comparison of muscle sizes.

In our study, mean diameter of extraocular muscles are 3.5 mm for medial rectus, 3.6 mm for lateral rectus, 4.2 mm for superior rectus-levator complex, and 3.9 mm for inferior rectus. The current study data were compared to the mean muscle diameters obtained in other previous studies as shown in Table 4. In comparison to the previous studies which shows similar ranking of extraocular muscle thickness, inferior > superior > medial > lateral, our study shows that the thickness of superior complex and lateral rectus were slightly larger. This variation in the thickness of muscles may be due to the genetic causes, that is why there is a need to establish normative data for patient populations of different races and ethnicities.

The sum of the diameters of all extraocular muscles can aid as an overall index to evaluate patient's measurements, especially in patients with Grave's disease, where the diameter of the individual muscle remains within the normal range, although the muscle is actually minimally enlarged. The inferior rectus muscle is the first and most commonly involved muscle. [(6)] In present study the sum of diameters of all extraocular muscles is 14.9, which is smaller than the previous studies done in western world as depicted in Table 4. Our study revealed that the mean diameters of the extraocular muscles in males are little larger than females.

The increase in the optic nerve complex diameter is an indirect indicator for the increased intracranial pressure. This measurement is utilized in the evaluation of graves orbitopathy, traumatic brain injury, glaucoma, patency of ventriculo-peritoneal shunt, or other causes of raised intracranial pressure. [(7-11)] In present study, the mean diameter of optic nerve-sheath complex is 4.4mm which is corroborating with the previous studies done by Nugent et al [(11)] and Demer et al [(12)] showing 4.2mm and 4.4 mm respectively.

The mean normal globe position is 8.1 mm on axial scans in our study which is slightly less than that reported by Ozgen et al [(13)] (9.9mm) and Demer et al [(12)] (9.4mm) in their studies.

Orbital hypertelorism is a manifestation of different craniofacial deformities such as craniofacial dysplasias, Apert and Crouzon syndromes, etc. [(14)] It is characterized by increased interorbital distance. Similarly, hypotelorism may be associated with various pathologies such as holoprosencephaly and craniosynostosis. [(15)] In male patients the mean interzygomatic line length is also significantly higher than in female patients in the current study. This is in accordance with the larger head size usually found in males. [(16,17)]

Conclusion

Our study has done an attempt to give normative mean measurements for different orbital structures that are essential to physicians, ophthalmologists, and radiologists for diagnosing and treating various orbital diseases.

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Legends Table and Figure

Table 1. Normal orbital measurements as seen on CT.

Measurements	Mean (mm)	Normal Range (±2 SDs) (mm)	Difference Range [a] (mm)
Medial rectus	3.5	3.2-3.7	0.5
Lateral rectus	3.6	1.8-4.9	0.8
Superior group	4.2	2.4-5.4	0.7
Inferior rectus	3.9	2.5-5.3	1.2
Sum of all muscles	14.9	11.5-17.8	1.3
Optic nerve-sheath complex	4.4	3.2-5.7	0.8
Globe position [b]	8.1	6.2-10.5	1.0
lnterzygomatic line	96	89-101	

Note: Medial and lateral rectus muscles were measured on axial plane, and superior group and inferior rectus muscle were measured on coronal plane at window level and width settings of 90 and 350 HU, respectively. The diameter of each muscle was measured at its maximum.

[a] Difference range between right and left orbit data in 95th percentile limits.

[b] Perpendicular distance between interzygomatic line and posterior margin of the globe.

Table 2. Normal orbital measurements (Mean ± 2 standard deviation) (in mm) as seen on CT according to gender.

Measurements	Male+Female	Male	Female
Medial rectus	3.5±1.4	3.7±1.2	3.4±1.2
Lateral rectus	3.6±1.4	3.8±1.4	3.4±1.1
Superior group	4.2±1.5	4.1±1.5	4.0±1.4
Inferior rectus	3.9±1.4	4.0±1.4	3.9±1.2
Sum of all muscles	14.9±3.4	14.9±3.6	14.9±3.2
Optic nerve-sheath complex	4.4±1.5	4.5±1.4	4.1±1.4
Globe position *	8.1±2.4	8±2.4	8.1±2
Interzygomatic line	96±6.1	98±7.2	95±6.4

*Perpendicular distance from interzygomatic line to posterior margin of globe.

Table 3. Normal orbital measurements (Mean ± 2 standard deviation) (in mm) as seen on CT according to age (in years).							
Measurements	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Medial rectus	3.3±1.2	3.5±1.2	3.6±1.1	3.8±1.1	3.8±1	3.6±1.2	3.5±1.1
Lateral rectus	3.5±1	3.6±1.1	3.8±1.1	4±1.2	3.9±1.1	3.4±1.1	3.4±1.1
Superior group	3.7±1.4	3.7±1.3	3.6±1.3	4.2±1.1	3.4±1.1	3.4±1.1	3.2±1.1
Inferior rectus	3.7±1.4	3.8±1.3	3.9±1.3	4±1.1	4±1.2	4±1.2	3.8±1.1
Sum of all muscles	14±3.4	14.2±3.5	14.4±3.4	14.6±3.3	14.3±3	14.3±3	14.1±3
Optic nerve-sheath complex	4.1±1.4	4.3±1.1	4.2±1.1	4.5±1.2	4.2±1.1	4.2±1.1	4.1±1.1
Globe position *	8.1±2.4	8.3±2.5	8.6±2.3	8.9±2.1	8.1±2	8.1±2	8.1±2
Interzygomatic line	95±6.8	96±6.3	97±6.5	98±6.2	96±6.1	95±5.8	95±5.8

*Perpendicular distance from interzygomatic line to posterior margin of globe.

Table 4. Normal measurement (in mm) of extraocular muscles comparing with the previous studies.					
Study	Medial rectus	Lateral rectus	Superior group	Inferior rectus	Sum of all muscles
Jacob (1980)	3.7	1.3	6.5	4.5	19.7
Nugent (1990)	4.1	2.9	3.8	4.9	18.1
Ozgen (1998)	4.2	3.3	4.6	4.8	16.9
Jong Soo Lee (2001)	3.7	3.4	4.0	4.1	14.0
Lerdlum (2007)	3.7	3.6	3.8	4.0	15.0
Present study	3.5	3.6	4.2	3.9	14.9

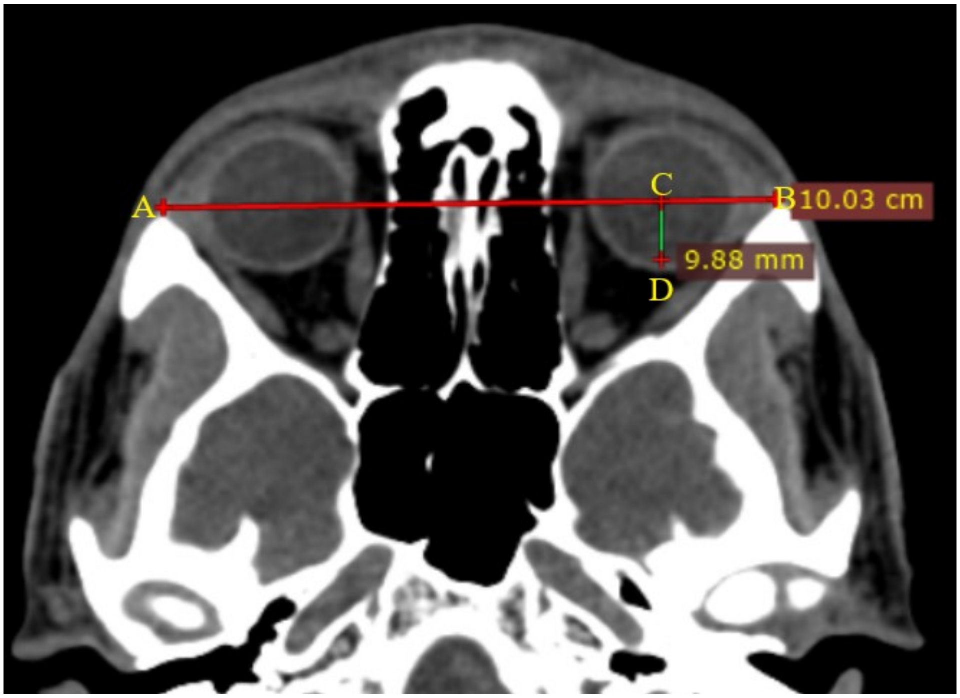

Figure 1: Axial CT image at midglobe level showing interzygomatic line (A-B) and perpendicular distance from interzygomatic line to posterior margin of globe (C-D).

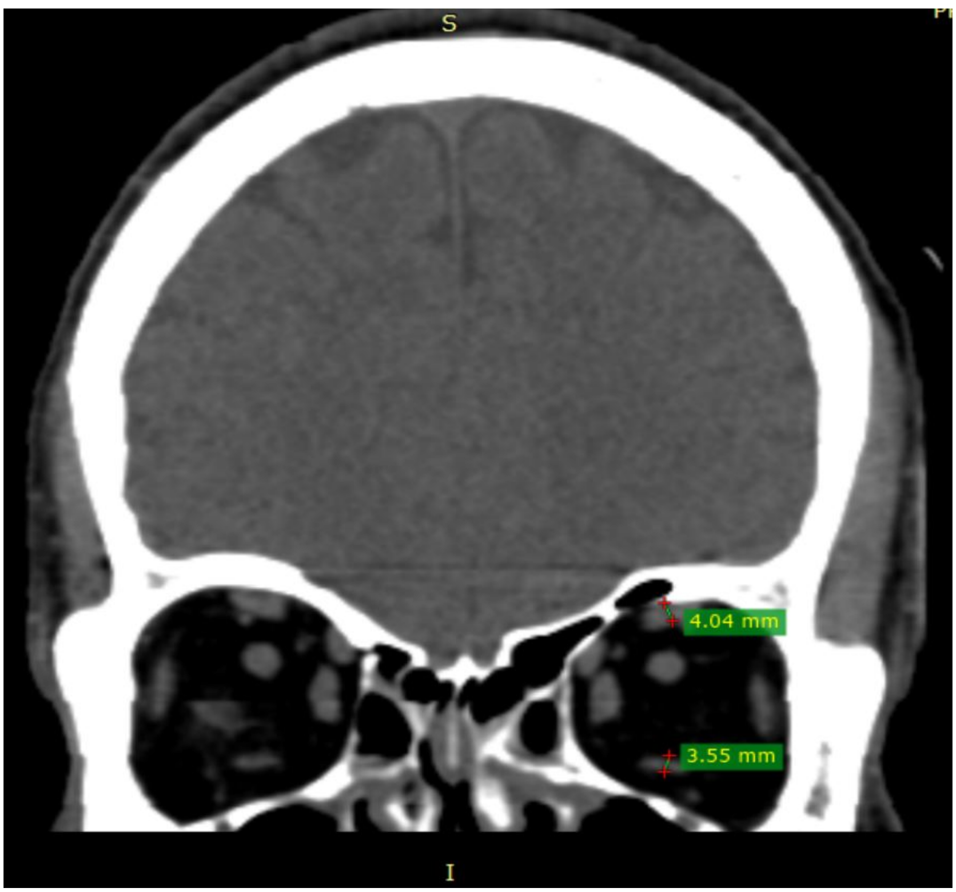

Figure 2: Coronal CT image showing maximum diameter of superior muscle group and inferior rectus muscle.