BUMJ
Benghazi University Medical Journal
Faculty of Medicine University of Benghazi
Volume/1 Issue/1 December 2024

Estimation of Eyeball Volume using computed tomography in a sample of Libyan population

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Original Research Article

Abstract

Background: A few ocular illnesses that change the eye's dimensions may cause visual anomalies such as myopia, hypermetropia, presbyopia,macrophthalmia, microphthalmia, and astigmatism. In accordance, the knowledge of eyeball volume is mandatory; its significant is quite clear in understanding illnesses such as Coats' disease, phthisis bulbi, and persistently hyperplastic primary vitreous that are linked to decreased ocular volume.

Aim: This study aims to evaluate eyeball volume using computed tomography in a Libyan population to be used as a reference in diabetic retinopathy (DR) and macular edema screening programs.

Patients & Methods: This is a retrospective study of the CT medical records of 100 consecutive subjects aged 20 to 80 years who were scanned in the diagnostic radiology department of the National Cancer Center, of Benghazi (NCCB) for different causes during the period from December 2023 to April 2024.

Results: This study included 100 patients; 63 (63%) were males, and 37 (37%) were females. The mean age was 43.12 ± 25.24 years for males and 41.24 ± 31.73 years for females. There was no statistically significant difference in the mean age between both sexes. There was no statistically significant difference in the mean eyeball volume for both sexes concerning age. The right eyeball volume was higher for both males and females.

Conclusion: Ocular volume correlated positively with the age of the patients, and males had slightly larger eyeballs compared to females. This data might be useful in ophthalmological, oculoplastic, and neurological practice. The right eyeball volume was higher on the right for both males and females.

Keywords: Computed tomography, eye volume, ocular volume, Libya.

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Introduction

Eyeball volume estimation is essential in ophthalmology because of its clinical significance. Despite its importance, this field has received relatively low attention, as it does not directly impact human health. [1] Therefore, knowing the eyeball volume can help in planning treatment or surgical application, as well as for monitoring the impact of specific disorders. [2] Understanding the anatomical variations between different small-eye disorders and the diseases that may be linked with each might help design surgical techniques for reducing complications and optimizing positive outcomes. [3]

In ophthalmology, eyeball trauma, cancer, congenital glaucoma, retinoblastoma, and some other disorders can change the size of the eyeball.[4] The oblate/prolate shapes of the eyeball can be traced already in newborns and can influence the development of myopic refractive errors .[5]

More recent CT scans have improved oculometric studies and allowed for the measurement of ocular size. By using these data, the link between ocular volume, age, and sex can be better understood. [4]

Computed tomography is a non-invasive method of measuring ocular dimensions, although it exposes users to ionizing radiation. When compared to other imaging modalities for in-vivo assessment, computed tomography (CT) provides precise measurement values. While the ionizing radiation effect restricts its normal use, CT can be deemed indispensable in situations when conventional methods of precise ocular dimension measuring are either unsuitable or contraindicated. It provides anatomical information about the surrounding soft tissues and bony components of the eye in addition to its capacity to assess dimensions. Additionally, various associated extra-ocular abnormalities, such as cerebral tumors, may be found during a single examination. [6]

Aim of the Work

The objective of the study was to evaluate normal eyeball volume using computed tomography and determine normative data for the Libyan population.

Patients and Methods

This is a retrospective study of the CT medical records of consecutive 100 subjects aged 20-80 years in the diagnostic radiology department of the National Cancer Center, Benghazi (NCCB) from December 2023 to April 2024.

The cohort included cases that were scheduled for CT scans of the head and neck area. These scans were requested by the emergency room due to various medical circumstances in each case. For this investigation, we focused only on instances that did not involve any neurological or ophthalmological conditions. The exclusion process included patients with known ophthalmologic or neuro-ophthalmologic conditions, as were those with orbital and ocular trauma.

The CT GE Revolution scanner was the one that was utilized. The axial length or ante-

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rior-posterior diameter of the eyeball was used to measure the ocular dimensions, which also included the anterior chamber depth, lens thickness, and vitreous length. The visual axis is defined as the distance that runs through the anterior corneal surface to the posterior wall of the sclera in an axial view. The maximum transverse distance (retina to retina) in axial view between the temporal and nasal ends of the globe's inner side was used to define the breadth, also known as the transverse diameter. The overall volume of the eye was computed using the averages of the length and breadth parameters = anterior-posterior diameter (cm), that is, axial diameter of the eyeball, TR = transverse diameter (cm) of the eyeball.

Rationally the eyeball is ellipsoidal in shape, however, it is assumed to be spherical for volume estimation by using the following formula,[7] $V = 4/3\pi r^3$ (cm^3), where r = (AP + TR)/4; AP = anterior-posterior diameter (cm), that is, axial diameter of the eyeball, TR = transverse diameter (cm) of the eyeball The dimensions were measured twice by the 2 researchers and the average recorded.

Statistical analysis

The statistical software SPSS version 21.0 was used to do the statistical analysis after the data were imported into Microsoft Excel. The qualitative (categorical) variables were presented as percentage and frequency, and the quantitative (numerical) variables were represented by mean and SD. The frequency was compared using the Chi-square test, while the mean values between the two groups were compared using the Student's t-test. When the P-value was less than 0.05, it was considered significant.

Results

Table 1: Distribution of the subjects by age and sex

	Male	Female	Frequency (%)
Age			
21–30	11 (17.5)	7 (18.9)	18 (18)
31–40	4 (6.3)	6 (16.2)	10 (10)
41–50	9 (14.3)	7 (18.9)	16 (16)
51–60	19 (30.2)	8 (21.7)	27 (27)
61–70	15 (23.8)	6 (16.2)	21 (21)
71–80	5 (7.9)	3 (8.1)	8 (8)
Mean age	43.12 ± 25.24	41.24 ± 31.73	
Total	63 (100)	37 (100)	100 (100)

The study population consisted of 100 subjects, with 63 males (63%) and 37 females (37%). The participants' ages ranged from 20 to 80 years. The mean age was 43.12 ± 25.24 years for males and 41.24 ± 31.73 years for females. There was no statistically

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significant difference in the mean age between the two sexes (P = 0.12). (Table 1).

Table (2): Mean eyeball volume of both eyes according to age of the male subjects studied

	Frequency (n)	Right eye volume (cm^3)	Left eye volume (cm^3)
Age			
21–30	11	5.9±0.29	5.6±0.14
31–40	4	5.85±0.27	5.95±0.32
41–50	9	6.1±0.27	5.9±0.27
51–60	19	6.3 ±0.34	5.8±0.29
61–70	15	6.7±0.23	6.5±0.32
71–80	5	7.1 ±0.31	6.90±0.30
Total	63	6.45 ±0.25	6.25±0.30

Table (3): Mean eyeball volume for both eyes concerning age of the female subjects studied.

	Frequency (n)	Right eye volume (cm^3)	Left eye volume (cm^3)
Age			
21–30	7	5.85 ± 0.32	5.75 ± 0.42
31–40	6	5.65 ± 0.27	5.6 ± 0.32
41–50	7	5.95 ± 0.35	5.9 ± 0.32
51–60	8	6.15± 0.24	6.1±0.29
61–70	6	6.5±0.18	5.45±0.32
71–80	3	6.95±0.42	6.84±0.25
Total	37	6.37±0.35	6.19 ±0.38

The mean eyeball volume for both sexes, categorized by age, is presented in Tables 2 and 3. The analysis indicates that the mean eyeball volume is slightly larger in males compared to females. Specifically, the measurements are as follows: for males, the right eye has a volume of 6.45 ± 0.25 cm^3, and the left eye is 6.25 ± 0.30 cm^3. For females, the right eye measures 6.37 ± 0.35 cm^3, while the left eye measures 6.19 ± 0.38 cm^3. Additionally, the volume of the right eyeball was greater than that of the left for both males and females, although this difference was not statistically significant (P = 0.11). Overall, the patterns of eyeball volume were similar for both genders.

Discussion:

Computed tomography (CT) has been a standard tool in ophthalmology for many years, offering thorough investigations. Thus, despite being valuable for diagnosing various neurological problems as well as vi-

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sual diseases, the gross anatomy of the eye receives less attention. In ophthalmology, the size of the eyeball may change due to various conditions, including retinoblastoma, congenital glaucoma, cancer, and trauma. [2]

This is a retrospective study analyzing the CT medical records of 100 consecutive subjects from various age groups, ranging from 20 to 80 years old. These subjects were admitted to the Diagnostic Radiology Department of the National Cancer Center, Benghazi (NCCB), between December 2023 and April 2024. The purpose of the study was to evaluate normal eyeball volume using computed tomography and to establish normative data for the Libyan population.

This study demonstrated a gradual increase in eyeball volume with age, with older age groups exhibiting the highest values for both males and females. This trend can be attributed to the continuous growth of the eyeball over time, and it was particularly pronounced in males.

One possible explanation for this finding is that the eyeball functions as a pressurized chamber, with the corneoscleral coat confining the intraocular pressure. This helps maintain the eye's dimensions, with the uveal circulation serving as the source of intraocular fluid. As a result, ocular pressure remains stable throughout life, even in older individuals. Overall, this leads to a consistent preservation of adult eyeball diameter once the maximum size has been reached or even a gradual increase of these values among elderly subjects.

In their study, Ogbeide and Omoti [8] reported an increase in eyeball dimensions with age. They found that eyeball growth was not related to the growth of skeletal, genital, or lymphoid systems. Instead, it resembled the growth patterns of the brain and central nervous system rather than those of the entire body. The results also indicated that both the eye and brain exhibit unique precocious growth during the active growing phase. Furthermore, the findings were comparable to those of Sahin et al. [9]

The orbit and ocular volumes may now be quantified volumetrically thanks to sectional imaging methods. Magnetic resonance imaging (MRI) offers the best resolution for soft tissue contrast and allows for multiplanar imaging without the use of ionizing radiation. However, CT imaging remains a powerful tool for providing a precise representation of skeletal structures. CT provides higher spatial resolution than MRI, making it superior for imaging small structures and displaying fine details, particularly in skeletal anatomy.[10]

Tabernero & Schaeffel [(11)] stated that the eyeball sizes and shapes differed significantly across the participants. In actuality, the transverse diameter difference between the eyes measuring 21 mm and 27 mm is greater than half a centimeter. The extremes do exist, even though they are uncommon. The axial diameter of the eye is altered by myopia and hypermetropia, but other siz-

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es remain the same. Thus, we recommend determining the transverse diameter for a feasible assessment of the eyeball size in an ophthalmologic or neurologic clinic. There is a correlation between the transverse diameter and the orbit breadth. Thus, this diameter can also be helpful in oculoplastic computations. However, there is no relationship between the depth of the orbit and myopic and hypermetropic increases in anteroposterior (axial) diameter.

regarding the investigation's methodology, CT is frequently performed as a first line of inquiry in emergency rooms and is commonly utilized in ophthalmology. Computed tomography has been used to measure normal in vivo ocular size at least since the early underestimated by CT measurements of the ocular diameters [12]. Accurate results are also obtained from CT measurements of the ocular diameters published by other authors. Although measuring sagittal diameter with CT is a little complex, there were no obstructions that could have affected the accuracy of the data when measuring transverse and axial (anteroposterior) diameters. [2]

Limitation:

The clinical application of the study and its usefulness have not been discussed in this study, which could have further enhanced its usefulness.

Conclusion:

This study has provided reference values for eyeball volumes in a sample of Libyan individuals. The findings indicate that ocular volume positively correlates with patient age and that males generally have slightly larger eyeballs than females. These data could be beneficial in ophthalmology, oculoplastic surgery, and neurology.

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