Original Article

Measurement of Orbital Dimensions and Its Gender Related Differences in Various Ages of Pakistani Children

PJO – Official Journal of Ophthalmological Society of Pakistan

Nazia Qidwai[1], Shabih Zehra[2], Maria Hameed[3]
Tauseef Mehmood[4], WejaiKumar[5]
[1,2,4]Al-Ibrahim Eye Hospital, Malir Karachi, [3,5]Jinnah Postgraduate Medical Center, Karachi

ABSTRACT

Purpose: To measure theorbital dimensions and their gender related differences at various ages in Pakistani children from birth to 12 years of age.

Study Design: Cross sectional observational.

Place and Duration of Study: Tibri Medical College and Hospital Karachi and National Institute of Child Health, Karachi from June 2022 to February 2023.

Methods: Patients who underwent CT Scan head for any reason but with normal orbits were included in the study. The vertical and horizontal measurements were made for anterior, middle and posterior orbit in sagittal and axial views.

Results: The mean age of the total sample of 176 children was 6.45±3.40 years. The mean horizontal dimension of the anterior side of the orbit was 28.31 mm for children aged 1-3 years, 30.63 mm for those aged 4-6 years, 32.22 mm for ages 6-9 years, and 32.93 mm for ages 10-12 years. These differences were statistically significant ($p<0.05$). A significant difference was observed in the mean vertical dimension for the middle and posterior sides across different age groups. There were significant differences in the vertical and horizontal dimensions of the anterior and middle sides of the orbits for children aged 1-3 years ($p<0.05$). However, for children aged 4-6 years, there were no significant differences between genders in any measured dimension (horizontal, vertical, or depth) ($p>0.05$).

Conclusion: There is a phase of rapid growth from birth to 3 years of age, after which the orbit continues to grow slowly. Gender-related differences were more pronounced during this phase.

Key Words: Orbit, Anthropometry, Cephalometry, Computed Tomography.

How to Cite this Article: Qidwai N, Zehra S, Hameed M, Mehmood T, Kumar W. Measurement of Orbital Dimensions and Its Gender Related Differences in Various Ages of Pakistani Children. 2024;40(3):257-262.
Doi:10.36351/pjo.v40i3.1777

Correspondence: NaziaQidwai
Al-Ibrahim Eye Hospital, Malir Karachi
Email: nazia_qidwai@hotmail.com

Received: November 11, 2023
Accepted: May 25, 2024

INTRODUCTION

Knowledge of various anthropometric measurements of the growing orbit at each year of childhood development is crucially important in cases of orbital fracture, facial and orbital bony abnormalities and reconstruction after enucleation and exenteration. The empty orbit has a tendency to contract if left unsupported by any implant, which would progressively maintain the appropriate orbital size. Postsurgical radiation also contributes to orbital retardation by damaging the proliferative cells inside the growth plates.[1] It is essential to prevent this resultant orbital contracture as early as possible to avert facial deformity resulting from injury to the orbit. This helpsinpreoperative planning of patients for reconstruction following trauma and orbital deformity.[1]

Having the knowledge of orbital measurements will help in making an age-appropriate orbital implant to maintain orbital growth hence avoiding craniofacial deformation in adulthood.[1,2] This results in adequate stimulation of orbital bones which leads to partial or even full development and reduces the risk of craniofacial deformation in adulthood.[3]

Ithas been reported that the orbital growth occurs at different speeds in different phases of life and is rapid in the first 3 years of life.[4] Variation has also been observed in the growth of the various orbital dimensions at different ages. A study showed that the orbital width and height decrease while its depth increaseswith age in both genders.[5] Yet another study showed a positive linear relationship between orbital volume and age in children from 0 to 6.It also showed no difference between the volume of both the orbits and that in both gender till 6 years of age.[6] It is also important to know the age at which gender related differences start to occur in orbital growth which will have impact on reconstruction of the orbit and implant used.

Having the knowledge of the growth curve and the relationship between head size and orbital depth can augment in improving safety and efficacy in pediatric orbital reconstructions.[7] Radiological evaluation is the method of choice for measuring the orbital dimensions. Different authors have employed different parameters and dimensions of the orbit and skull to obtain race-related differences. A thai study included morphometric data of the orbital fissures and foramina in the orbits.[8] Nitek et al, showed that the intraorbital distances can be determined on the basis of gender, length and height of the skull, the width of the orbit, and the orbital coefficient.[9] Anthropometric measurements carry risk of error as patient co-operation is much required.[10] Cephalometric measurements require less patient cooperation but use ionizingradiation and involve nonstandardized magnification factors, which can lead to uneven landmark positioning.[11]

Children of various race, ethnicity and geographical locations have also shown variation in orbital volume measurements.[12] CT has high accuracy in looking at bony pathologies. It is also reproducible due to 3-dimensional image capabilities.[13] However, as there is risk of radiations in Paediatricpopulation, orbital dimensions of different races have limitedly been evaluated in this age.[14-16] Hence keeping in view the above factors, more studies from the various regions of the world are required.In this study, we utilized CT scans from pediatric patients who had undergone scanning for unrelated conditions but exhibited normalskull and orbit.

METHODS

This was a cross-sectional study conducted at two hospitals; Isra Postgraduate Insitute of Ophthalmology, Tibri Medical College and Hospital Karachi and the National Institute of Child Health, Jinnah Postgraudate Medical Center, Karachi. After ethical committee approval, data was collected from CT scan of children of ages 0 to 12 years with no orbital pathology. Sample size was calculated from Open Epi sample calculator by using mean difference of orbital volume of boy (16.71 ± 1.26 cm^3) and girl (17 ± 0.88cm^3), keeping 70% power and 95% confidence interval.[17] Sample of 174 patients was collected through non probability convenient sampling. Patients who underwent CT Scan head for any reasonbut with normal orbits were included in the study. Informed consent waiver wasobtained at both the centers as the data was anonymously used.Patients with any congenital skull or orbital abnormality or fractures or facial disorder were excluded from the study.Datawasrecorded for every year of age from both gender and of any ethinicity.

The CT Scanmachineused at the Tibri Medical College and Hospitalwas Hitachi Supria 16/32, with current 150mA, voltage 220v and pitch distance 2.5 to form a matrix of pixels with a 220mm field of view. The graphic processing software that came with the CT machine was used to perform manual tracing of the orbital boundaries. The level was set to the one having the largest diameter for both eyeballs, the centers of the crystal lens and the optic nerves showing the entire intraocular pathway, with the lateral orbital rim shown as the lowest points. All of the measurements were done on this level of scan**.** Non-enhanced computed tomography images of Head and neck were obtained. Image slicing was 1-3mm and soft and bone window of 450 × 101 Hounsfield units (width × height). At Jinnah Postgraudate Medical Center, Toshiba 16 slicer aquilionlitening machine was used with slice thickness of 7 mm, pitch: 1 tube potential 120 kv and tube charge per gantry rotation, 25-50 m.

Key points of measurements were decided by the ophthalmologist and radiologist together. Measurements at both the centers were conducted exclusively by individual radiologists to reduce the potential for errors in data collection.The skull wasleveled in the transverse plane, using the cochlea as a reference point to adjust left and right into the same image. In the sagittal plane, orientation was in Frankfort horizontal plane (the highest point on the upper margin of the opening of each external auditory canal and the most inferior point of the left orbit). Horizontal and vertical measurements were assessed most anteriorly, in the middle of the orbit and at the most posterior end. The posterior limit was set at the opening of the optic foramen into the orbit.The anterior horizontal orbital diameter was evaluated by measuringthe maximum distance between medial and lateral orbital walloncoronalscan.Anteriorvertical distance was measured between superior and inferior orbital rim. Orbital floor depth was taken as the distance from the most anterior projection of the inferior orbital rim to the inferomedial aspect of the optic canal.

Data was analyzed by using SPSS version 22.0. After conducting a Shapiro-Wilk test to assess the normality of the data, it was determined that the data followed a normal distribution.Mean±S.D was calculated for age (continuous variable). Pie chart was made for age groups (categorical variable). One way ANOVA was used to compare mean orbital dimensions among different age groups. Independent sample t test was used to compare mean orbital dimensions gender-wise. P-value < 0.05 was considered statistically significant.

RESULTS

A total of 176 children were recruited to measure horizontal, vertical and depth dimensions of orbital volume. Mean age of the children was 6.45±3.40 years (minimum was 1 year and maximum was 12 years), consisting of 111 (63.1%) boys and 65 (36.9%) girls. Boy to girl ratio was 1.7:1. Age distribution is shown in figure 1.

The mean horizontal dimension of the anterior orbit for children aged 1-3 years was 28.31 ± 3.59 mm, for ages 4-6 years it was 30.63 ± 1.92 mm, for ages 6-9 years it was 32.22 ± 1.86 mm and for ages 10-12 years it was 32.93 ± 3.25 mm (p<0.05). Likewise, significant differences in mean horizontal dimensions for the middle and posterior orbit were observed across different age groups (p < 0.05). For vertical position by age groups, significant difference was

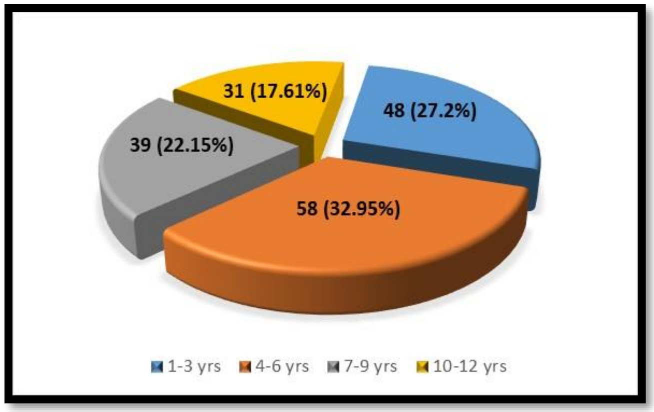

Fig. 1: Age Distribution of study children.

found among the various age groups. Mean dimension of anterior orbit for age 1-3 years was 23.16±4.50 mm; for 4-6 years, 25.77±3.27 mm; for 6-9 years, 27.91±2.60 mm and for 10-12 years, 27.43±2.70 mm. (p<0.05). Moreover, age wise significant difference was also found in mean vertical position for middle and posterior orbit. (p<0.05). Similarly, significant difference was also found in depth dimensions among different age groups (p<0.05) **(Table 1).**

Table 1: *Age-wise comparison of orbital dimensions.*

	Dimension	Age Range	N	Mean±S.D	p-value
Horizontal	Anterior	1-3	48	28.31±3.59	0.001
		4-6	58	30.63±1.92	
		7-9	39	32.22±1.86	
		10-12	31	32.93±3.25	
	Middle	1-3	48	18.32±2.25	0.001
		4-6	58	19.21±2.34	
		7-9	39	19.13±1.94	
		10-12	31	20.45±2.14	
	Posterior	1-3	48	3.98±0.81	0.001
		4-6	58	4.05±0.97	
		7-9	39	4.80±0.93	
		10-12	31	3.90±0.76	
Vertical	Anterior	1-3	48	23.16±4.50	0.001
		4-6	58	25.77±3.27	
		7-9	39	27.91±2.60	
		10-12	31	27.43±2.70	
	Middle	1-3	48	19.10±3.75	0.001
		4-6	58	20.02±2.15	
		7-9	39	21.76±3.08	
		10-12	31	22.50±2.13	
	Posterior	1-3	48	3.62±0.93	0.001
		4-6	58	3.98±1.08	
		7-9	39	4.59±1.01	
		10-12	31	3.90±0.65	
Depth		1-3	48	37.02±4.53	0.001
		4-6	58	41.24±2.32	
		7-9	39	41.93±3.18	
		10-12	31	42.10±3.37	

Table 2: *Gender wise comparison of orbital dimensions.*

Dimensions (mm)		Age (years)											
		1-3			4-6			7-9			10-12		
		Gender	Mean±S.D	p-value	Gender	Mean±S.D	p-value	Gender	Mean±S.D	p-value	Gender	Mean±S.D	p-value
Horizontal	Anterior	M=31	29.03±3.19	0.09	M=35	30.76±1.76	0.91	M=24	32.30±1.79	0.68	M=21	33.37±3.36	0.19
		F=17	27.11±4.12		F=23	30.69±2.31		F=15	32.07±1.97		F=10	32.02±2.74	
	Middle	M=31	18.67±2.21	0.03	M=35	19.30±1.31	0.61	M=24	19.28±1.85	0.58	M=21	20.51±1.81	0.8
		F=17	16.33±4.81		F=23	18.92±2.94		F=15	18.96±2.01		F=10	20.34±2.70	
	Posterior	M=31	3.86±0.65	0.51	M=35	4.15±0.92	0.49	M=24	4.83±0.85	0.37	M=21	4.02±0.67	0.13
		F=17	4.01±0.84		F=23	3.94±0.98		F=15	4.59±0.93		F=10	3.67±0.75	
Vertical	Anterior	M=31	24.39±4.10	0.01	M=35	25.78±2.81	0.99	M=24	28.39±2.31	0.14	M=21	27.80±2.55	0.16
		F=17	21.01±4.55		F=23	25.77±3.85		F=15	27.23±2.93		F=10	26.60±2.78	
	Middle	M=31	19.97±3.21	0.02	M=35	20.20±1.93	0.47	M=24	21.82±2.87	0.88	M=21	23.20±1.68	0.002
		F=17	17.46±4.09		F=23	19.72±2.32		F=15	21.69±3.37		F=10	21.18±1.15	
	Posterior	M=31	3.61±0.82	0.44	M=35	3.92±1.06	0.93	M=24	4.81±1.01	0.03	M=21	4.03±0.63	0.15
		F=17	3.82±0.93		F=23	3.89±1.03		F=15	4.12±0.77		F=10	3.73±0.60	
Depth		M=31	37.72±5.01	0.16	M=35	41.48±1.88	0.38	M=24	42.05±3.09	0.76	M=21	42.54±2.91	0.26
		F=17	35.74±3.28		F=23	40.83±2.95		F=15	41.75±3.40		F=10	41.32±4.07	

Gender wise, significant difference was found in horizontal position of middle orbit. Moreover, significant difference was found in vertical position for both anterior and middle orbits for age 1-3 years($p<0.05$). However, no significant difference was found in depth dimension of orbit by gender ($p>0.05$). Similarly, no significant difference was found in any positions (horizontal, vertical and depth) for age 4-6 years by gender with $p>0.05$**(Table 2).**

DISCUSSION

Dimensionsof adult orbit have been given in various research papers but there is a lack of pediatric data.[17,18] Significance of having this data has been highlighted especially for orbital reconstruction after fractures.[19] The paediatric orbit is subject to change over the years of growth, the various orbital dimensions showing different phases, by speed. Smith et al, suggested that orbital volume continues to change until the late teens, with an approximate growth rate of 1–2% per year.[20] It has been seen that the fastest development of the eyeball occurs within the first year. It then reaches the axial length of 22.5–23 mm. Hence the 1st year is the crucial period for growth. After 3 years till 12 years of age the eyeball only increases by 1 mm in axial length.[21]

Researchers have assessed various orbital and skull parameters to evaluate age and race specific values and changes in human orbit. Pool et al, evaluated the intercanthal, bony interorbital, and bony lateral orbital distances.[22] No study to date exists on assessment of Pakistani children's orbits.

In our study a slight predominance was found for boys over girls. Similar feature was observed in studies by Nan Wei and Elkhamary SM et al.[23] There was a progressive increase in the horizontal and vertical dimensions of the orbit from birth to 12 years age. It was also observed that there was a fast phase of rapid growth from birth till 3 years of age. After this the orbit continued to grow slowly. These results affirm the work of other researchers. In the study by Nan Wei two fast growth phases were observed, one from birth to 3 years of age and other from 7 years to 12 years of age.[17] The first fast phase, mainly reflects the fast growth of facial bones, the eyeball and orbital bones. Such racial differences of orbital growth pattern have been observed in other studies.[23]

Gender variations were seen before 3 years of age in our study. Significant gender-based difference was found in horizontal and vertical planes of anterior and middle orbit. Dimensions of males were larger than that of females, especially in the first 3 years of life. However, in a study by Nan Wei et al, there was no significant difference in the growth pattern between boys and girls before 12 years age.[17]

Orbital depth increased rapidly in the first 3 years in our study after which there was a long phase of steady growth till 12 years of age. Escaravage et al, showed that the globe diameter and all length measurements increased most rapidly over the first 12 to 24 months and reached 86% to 96% of their respective adult means by 8 years. Afterwards, the rate slows remarkably until maturity.[24]

Having accurate measurements of paediatric orbits by age is also fundamental in orbital reconstruction and in avoiding optic nerve injury because we know that orbital trauma results in alteration of orbital volume and hence poor visual prognosis.[25] Knowing the orbital dimensions at various ages and understanding the growth pattern in different races would help in making appropriate custom-made implants to promote norm orbital growth.

Funding: None to declare.

Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review **board (REC/IPIO/2022/54).**

REFERENCES

1. **Hou ZJ, Xian JF, Chang QL, Wei W, Li D.** Digital evaluation of orbital development after self-inflating hydrogel expansion in Chinese children with congenital microphthalmia. J Plast Reconstr Aesthet Surg. 2016;**69:**706–714. Doi:10.1016/j.bjps.2016.01.011
2. **Lin HY, Liao SL.** Orbital development in survivors of retinoblastoma treated by enucleation with hydroxyapatite implant. Br J Ophthalmol. 2011;**95:**630–633. Doi:10.1136/bjo.2009.175778
3. **Gentry LR**. Anatomy of the orbit. NeuroimagClin N Am 1998;**8:**171–194.
4. **Morrow BT, Albright WB, Neves RI, Wilkinson MJ, Samson TD.** Orbital expansion for congenital anophthalmia may be achievable in infancy but not in childhood. J CraniofacSurg 2016;**27:**1642–1646. Doi:10.1097/SCS.0000000000002937
5. **Khademi Z, Bayat P.** Computed tomographic measurements of orbital entrance dimensions in relation to age and gender in a sample of healthy Iranian population. J CurrOphthalmol. 2016;**28:**81-84. Doi: 10.1016/j.joco.2016.03.002
6. **Yang G, Zhang Y, Chang Q, Li D.** Measurement of orbital development in children from birth to 6 years of age. Zhonghua Yan Ke Za Zhi. 2015;**51:**576–580. Chinese. PMID: 26696573.
7. **Chang JT, Morrison CS, Styczynski JR, Mehan W, Sullivan SR, Taylor HO.** Pediatric Orbital Depth and Growth: A Radiographic Analysis. J Craniofac Surg. 2015;**26(6):**1988-1991. Doi: 10.1097/SCS.0000000000001974.
8. **Huanmanop T, Agthong S, Chentanez V.** Surgical anatomy of fissures and foramina in the orbits of Thai adults. J Med Assoc Thai. 2007;**90(11):**2383-2391. PMID: 18181324.
9. **Nitek S, Wysocki J, Reymond J, Piasecki K.** Correlations between selected parameters of the human skull and orbit. Med Sci Monit. 2009;**15(12):**BR370-377. PMID: 19946226.
10. **Farkas LG, Hreczko TM, Katic MJ, Forrest CR.** Proportion indices in the craniofacial regions of 284 healthy North American white children between 1 and 5 years of age. J Craniofac Surg. 2003;**14(1):**13-28. Doi: 10.1097/00001665-200301000-00004.
11. **Farkas LG, Tompson BD, Katic MJ, Forrest CR.** Differences between direct (anthropometric) and indirect (cephalometric) measurements of the skull. J Craniofac Surg. 2002;**13(1):**105-108; Discussion 109-110. Doi: 10.1097/00001665-200201000-00024. PMID: 11887005.
12. **Jeong HC, Ahn HB.** Comparison of orbital anatomy in Korean and Caucasian patients using computed tomography. J Korean Ophthalmol Socie. 2015;**56:**1311-1315.Doi:10.3341/jkos.2015.56.9.1311
13. **Shaw RB Jr, Kahn DM.** Aging of the midface bony elements: a three-dimensional computed tomographic study. Plast Reconstr Surg. 2007;**119(2):**675-681; Discussion 682-3. Doi: 10.1097/01.prs.0000246596.79795.a8. PMID: 17230106.
14. **Rohrich RJ, Pessa JE.** Discussion. Aging of the facial skeleton: aesthetic implications and rejuvenation strategies. PlastReconstr Surg. 2011;**127(1):**384-385. Doi: 10.1097/PRS.0b013e3181fad698. PMID: 21200233.
15. **Grunwaldt L, Smith DM, Zuckerbraun NS, Naran S, Rottgers SA, Bykowski M, et al.** Pediatric facial fractures: demographics, injury patterns, and associated injuries in 772 consecutive patients. PlastReconstr Surg. 2011;**128(6):**1263-1271. Doi: 10.1097/PRS.0b013e318230c8cf..

16. **Martin MD, Rechner BP.** Dimensional considerations for operative repair of the fractured pediatric orbit. Plast Reconstr Surg. 2012;**129:**182e–183e. Doi:10.1097/PRS.0b013e3182365d3d
17. **Wei N, Bi H, Zhang B, Li X, Sun F, Qian X.** Biphasic growth of orbital volume in Chinese children. Br J Ophthalmol. 2017;**101(9):**1162-1167. Doi: 10.1136/bjophthalmol-2016-309848.
18. **Singh J, Rahman RA, Rajion ZA, Abdullah J, Mohamad I.** Orbital Morphometry: A Computed Tomography Analysis. J Craniofac Surg. 2017;**28(1):**e64-e70. Doi: 10.1097/SCS.0000000000003218.
19. **Magarakis M, Mundinger GS, Kelamis JA, Dorafshar AH, Bojovic B, Rodriguez ED.** Ocular injury, visual impairement, and blindness associated with facial fractures: a systematic literature review. Plast Reconstr Surg. 2012;**129:**227-233. Doi:10.1097/PRS.0b013e3182362a6d
20. **Smith EA, Halbach CS, Robertson AZ, Peterson AM, Harrison AR, Grünheid T, et al.**Orbital volume changes during growth and development in human children assessed using cone beam computed tomography. Head Face Med. 2022;**18(1):**8. Doi: 10.1186/s13005-022-00310-9.
21. **Li DM.** Give attention to standardized management of orbital development in Chinese withmicrophthalmos or anophthalmos. Zhonghua Yan Ke Za Zhi. 2013;**49(8):**676-678. Chinese. PMID: 24246803.
22. **Pool GM, Didier RA, Bardo D, Selden NR, Kuang AA.** Computed tomography-generated anthropometric measurements of orbital relationships in normal infants and children. J NeurosurgPediatr. 2016;**18(2)**:201-206. Doi: 10.3171/2016.2.PEDS15475.
23. **Elkhamary SM, Sallam AA, Kahtani EA, Souru C, Khandekar R.** Measurement of bony Orbital Volume with Computed Tomography (CT) in Healthy Eyes of Saudi Children. J Cancer Prev Curr Res. 2016;**6(4):**00215. Doi: 10.15406/jcpcr.2016.06.00215
24. **Escaravage GK Jr, Dutton JJ.** Age-related changes in the pediatric human orbit on CT. Ophthalmic Plast Reconstr Surg. 2013;**29(3):**150-156. Doi: 10.1097/IOP.0b013e3182859716.
25. **Bastos RM, Taparello C, Tres R, Sawazaki R.** Orbital Blowout Fracture With Globe Displacement Into the Maxillary Sinus: A Case Report and Literature Review. J Oral Maxillofac Surg. 2021;**79(1):**204.e1-204.e12. Doi: 10.1016/j.joms.2020.09.034.

Authors Designation and Contribution

NaziaQidwai; Assistant Professor:*Concepts, Design, Literature search, Data cquisition, Data analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

ShabihZehra; Assistant Professor: *Concepts, Design, Literature search, Data cquisition, Manuscript review.*

Maria Hameed; Assistant Professor:*Design, Data cquisition, Manuscript review.*

Tauseef Mehmood; Research Associate:*Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Wejaikumar; Consultant Ophthalmologist: *Data cquisition, Manuscript review.*

....☆....