Scholars Academic Journal of Biosciences (SAJB) **ISSN 2321-6883 (Online)**
Sch. Acad. J. Biosci., 2015; 3(7):618-623 **ISSN 2347-9515 (Print)**
©Scholars Academic and Scientific Publisher
(An International Publisher for Academic and Scientific Resources)
www.saspublishers.com **DOI :** 10.36347/sajb.2015.v03i07.009

Research Article

The craniometrical study of orbital base of Indian population and its applied importance

Dr. Gopalakrishna.K[1]*, Dr. Kashinatha Shenoy.M[2]
[1]Assistant Professor, Department of Anatomy, Malabar Medical College and Research Centre, Modakkallur, Atholi, Calicut, India.
[2]Associate Professor , Department of Ophthalmology, Malabar Medical College and Research Centre, Modakkallur, Atholi, Calicut, India.

***Corresponding author**
Dr. Gopalakrishna.K.
Email: gkemail01@gmail.com

Abstract: In Norma frontalis the orbital base appear equal. But dimensionally are they equal or different? By considering orbital index as reference measure this study was conducted to evaluate the significant variation and correlation in the dimensions of pairs of orbital base. This research study was done on 128 human orbits of Indian origin having regular shape. Damaged or deformed orbits were excluded. Orbital index was calculated. Orbits were categorized into Microseme, Mesoseme and Megaseme type. Paired t test with p-values < 0.05 was considered significant. Result: Bilaterally significant difference was found in vertical diameter (p=0.001) and in orbital index (p=0.011). But no significant difference was observed in horizontal diameter (p=0.23). The correlation between the vertical diameters (r=0.96), horizontal diameters (r=0.95) and orbital index (r=0.776) were found. The strength of relationship between the pair of orbits was up to 92.16% in vertical diameters, 90.25% in horizontal diameters and 60.22% in orbital index. The mean orbital index in present study was 80.69±2.19 (right) and 81.16±2.02 (left). Majority of orbits were of Microseme type 79.69% [right], 75.0% [left] followed by Mesoseme type 20.31% [right], 25.0% [left]. Orbital dimensions are essential for ophthalmologist, maxillofacial surgeon, forensic scientist, anthropologist, and anatomist and in preparation of spectacles. Conclusion: Even though dimensional laterality was observed in bilateral orbits, the strong relationship was found between them.
Keywords: orbital base, orbit, index, diameter, craniometrical, diameter.

INTRODUCTION

Orbital base is an important feature in Norma frontalis. They are present between neurocranium and splanchnocranium bilateral to the nasal root. It provides protection, spatial relationship between the two eyeballs and maintains the proper positioning of visual axis which is essential for conjugate eye movements and binocular vision [1]. Base of orbit is formed by frontal, zygomatic, maxilla and lacrimal bones. It has four margins. The superior margin is formed by frontal bone and it presents supraorbital notch. The lateral orbital margin by frontal and zygomatic bones and it has frontozygomatic suture which is a weak point and it is prone for injury. The inferior margin by maxilla and zygomatic bone and it is related with Infraorbital foramen. The medial margin is formed by maxilla, lacrimal and frontal bones. Orbital dimensions are crucial for ophthalmologist, maxillofacial surgeon, forensic scientist, anthropologist and anatomist [2]. On inspection the pair of orbital base appears proportionately equal in a skull. But dimensionally are they equal or different? To evaluate this question orbital index was taken as reference measure. The orbital index is the percent ratio of vertical with horizontal diameter and it expresses the change in the shape of orbital base in numerical form. This study is designed primarily to evaluate the significant variation, correlation in the dimensions of pairs of orbital base. Bony orbits were selected as units of investigation as it will be more realistic one.

MATERIALS AND METHODS:

This primary research study was done on orbits of sixty four dry adult human skulls (n=128 orbits) of Indian origin. They were selected by simple random sample method from the Anatomy Department, Malabar Medical College and Research Centre, Modakkallur, Calicut, Kerala, India. Study was conducted in the anatomy department during December 2013 to September 2014.

Study population: dry human skulls with pair of orbits who fulfilled the inclusion and exclusion criteria.

Pilot study: was conducted on twenty dry skulls to plan the design and necessary modifications.

Sample size calculation: it was done for precision of 0.5 mm and with minimal 80% of power.

Inclusion criteria: the orbits with regular shape are included.

Exclusion criteria: orbits having deformity and fracture are excluded.

Instruments: Magnifying lens, divider with fine tips, Vernier Caliper, camera were used.

Parameters:
1). Horizontal Diameter: the distance between the dacryon to orbital tubercle.
2). Vertical diameter: distance between superior and inferior margin at the midpoint and perpendicular to the horizontal diameter.
3). Orbital Index[2] = Vertical Diameter / Horizontal Diameter X 100.

Procedure: The orbital base was carefully inspected with magnifying lens. The measurements were performed with proper illumination by a vernier caliper. Average of three readings by single investigator was recorded in frequency tables on a work sheet. A master chart was prepared. Data analysis was done. Based on the orbital index [2], orbits were categorized into three types and arranged in class interval frequency table as follows-

1).Megaseme: orbital index ≥ 89.
2. Mesoseme: orbital index <89 and ≥83.
3. Microseme: orbital index < 83.

Statistical assessment: The descriptive, explorative and inferential assessments were applied on the collected data. The central tendency and measure of spread were calculated manually [3]. The comparison of vertical diameter, horizontal diameter and orbital index of bilateral orbital base were done by paired t-test [4]. Relationship and its strength between the study parameters of bilateral side were determined by constructing scatter diagram, Pearson correlation coefficient and regression analysis [4]. Statistical assessment with p-values < 0.05 was considered significant.

RESULT

The comparison of data from pair of orbits (Table-2) by paired t test shows significant difference in the vertical diameter (p=0.001) and orbital index (p=0.011). But Horizontal diameter has not shown significant difference (p=0.23).The relationship between the right and left side variables were assessed by Scatterplot (Figure-2). It shows strong positive linear correlation. Outliners were not found.

The orbits were categorized (table-2) on the basis of orbital index into Microseme, Mesoseme and Megaseme [2]. Prominent orbit type of Microseme was observed in this study, followed by Mesoseme type.

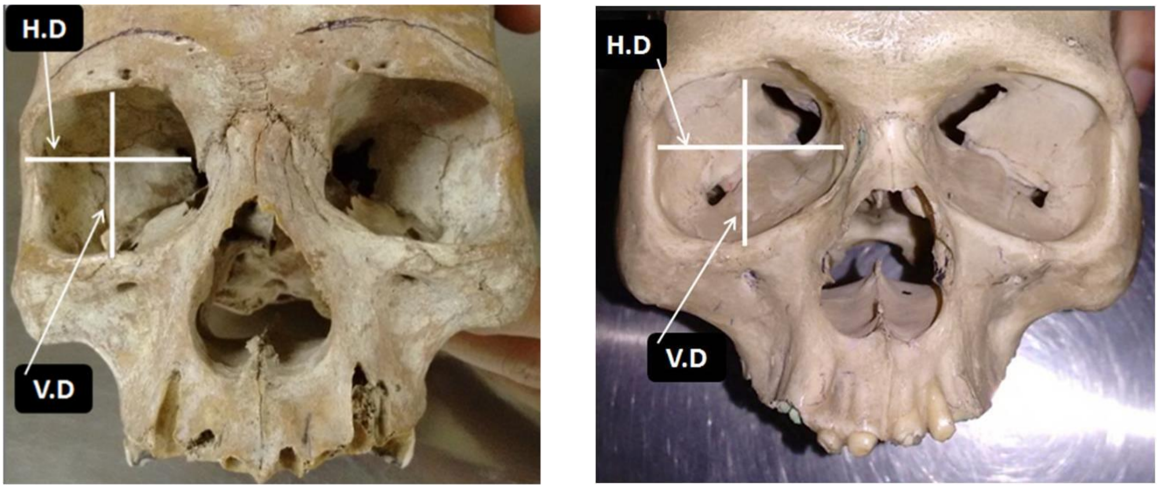

Fig-1: Orbital vertical diameter (VD) and horizontal diameter (HD).

Table-1:Findings of craniometry of the orbital base.

Parameter	Orbit	Mean ±SD	Min –Max	SE	p-value	r
Vertical diameter (mm)	Right	32.75±2.21	29.16-37.97	0.28	0.001	0.96
	Left	33.05±1.99	29.24-37.51	0.25		
Horizontal diameter (mm)	Right	40.62±3.06	34.85-45.07	0.38	0.23	0.95
	Left	40.75±2.69	35.04-46.62	0.34		
Orbital index	Right	80.69±2.19	72.55-85.71	0.27	0.011	0.776
	Left	81.16±2.02	72.96-84.89	0.25		
SD= Standard deviation, Min=minimum, Max-maximum, SE=Standard error, p-value =significance between bilateral side orbits, r=correlation coefficient.						

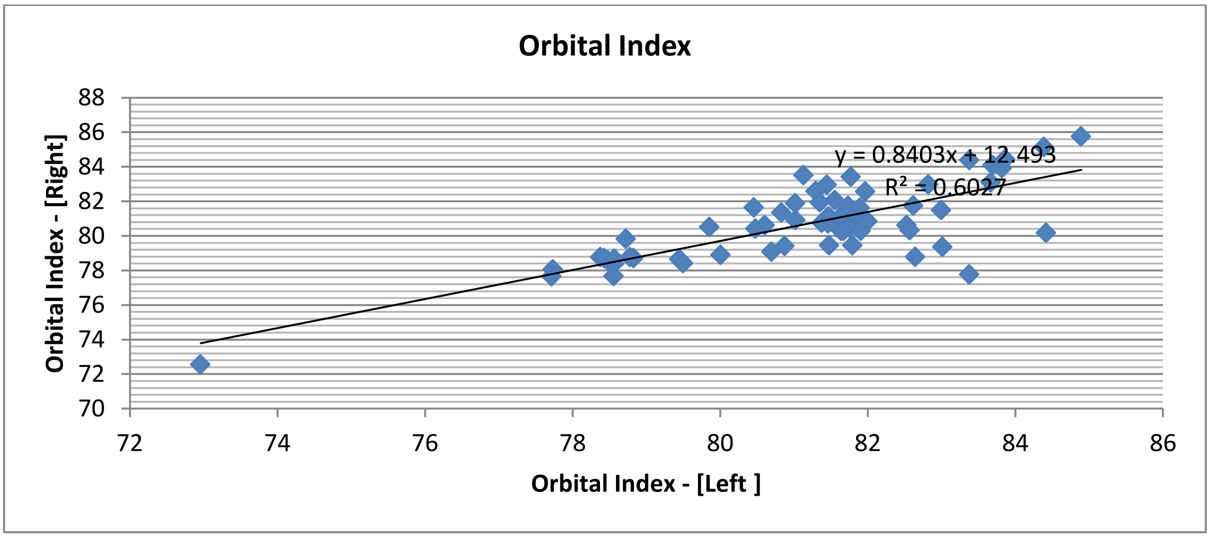

Fig-2: Scatterplot showing strong positive correlation (r=0.776) between the right and left orbital index, with least square regression line, regression model and coefficient of determination.

Table-2:Classification of orbits (n=128 orbits)

	Type	Right (=64)	Left(=64)
1	Megaseme [OI ≥ 89].	0/64, (0.0%)	0/64, (0.0%)
2	Mesoseme [89 >OI ≥83.]	13/64, (20.31%)	16/64, (25.0%)
3	Microseme [OI<83]	51/64, (79.69%)	48/64, (75.0%)
OI=Orbital Index			

DISCUSSION

In the present study the bilateral orbits shown significant difference in orbital index (p value=0.011) and in orbital vertical diameters (p value=0.001). The difference was not significant for the horizontal diameter (p=0.23). On exploration of data with the scatter diagram strong positive linear correlation was found between pair of orbits. The quantified correlation coefficient showed strong positive linear relationship for vertical diameters (r=0.96), Horizontal diameters (r=0.95) and orbital index (r=0.776). The coefficient of determination suggests that strength of relationship between the pair of orbits were up to 92.16% in vertical diameters, 90.25% in horizontal diameters and 60.22% in orbital index. Hence even though bilateral orbits had laterality, strong relationship was found between them. The mean orbital index in present study was 80.69±2.19 (right) and 81.16±2.02 (left). Majority of orbits were (table-2) of Microseme type 79.69% [right], 75.0% [left] followed by Mesoseme type 20.31% [right], 25.0% [left].

Comparison

The results were compared with the available other studies on different populations and they were presented in table-3.

1. Significant difference between bilateral orbits were reported by previous study [5] on Egyptian population in vertical and horizontal diameters (p<0.05). Where the orbital index has not shown significant difference (p=0.173). It could be due to the differential growth in the multiple bones forming the orbit. The orbits with proportionally larger horizontal than vertical diameter will have smaller orbital indices and wider orbit and face. While those with larger vertical than horizontal diameter will have larger orbital indices, narrow orbit and face.Hence orbital index indicates shape of orbit.
2. Inter-population and intra-population variations can be observed (table-3) by studies. Racial [6], intra-population, intra-racial [7, 8] variations were found. Also the environmental or ethnic differences, evolutionary, historical and genetic factors may account here. Display of Considerable or clear variability [9] in the orbit regarding its growth rate is reported.
3. The correlation between the vertical and horizontal diameter is proposed [10] by the previous study. The present study showed strong correlation bilaterally (table-1).

Table-3:Comparison of researches on different populations.

Researcher	Population	Orbital Index	Type	Vertical Diameter	Horizontal Diameter
Present study	Indian	80.69±2.19 (R), 81.16±2.02 (L).	Mesoseme (20.31%), Microseme (79.69%) [R]	32.75±2.21 [R] 33.05±1.99 [L]	40.62±3.06 [R], 40.75±2.69 [L]
			Mesoseme (25.0%), Microseme (75.0%) [L]		
Gosavi S.N et al [7]	Indian	81.88	Microseme	32.31 ±2.52	39.46 ± 2.57
Ebeye O.A et al [8]	Nigerian	78.15 ±0.82 [M], 78.57 ±0.6 [FM]	Microseme	30.01±3.22 [M], 31.92±3.07 [FM]	42.24±2.64 [M], 40.82±3.29 [FM]
		82.42±3.50 [M-L], 83.46±3.5 [FM-L			
Fathy A et al [5]	Egyptian	85.20±2.97 [M-R] 82.81±3.02 [M-L]	Mesoseme	35.83±1.23 [M-R], 35.27±1.35 [M-L]	43.62±1.13 [M-R], 42.6±0.96 [M-L]
		84.13±3.76[FM-R], 82.88±3.31[FM-L]	Mesoseme	35.53± 0.95 [FM-R], 34.71± 1.12 [F-L]	42.75±1.35 [FM-R], 42.0±1.37 [FM-L]
Leko Bankole J et al [11]	Nigerian Ikwerre	105.25± 10.77 [M]	Megaseme	44.06± 4.30 [M],	42.87± 4.60 [M],
		103.33±12.50 [FM]	Megaseme	44.26± 3.88 [FM]	42.37± 4.95 [FM]
	Nigerian Kalabaris	103.98± 8.22 [M]	Megaseme	42.67± 3.48 [M]	41.14± 3.09 [M]
		102.92± 9.49 [FM]	Megaseme	42.22± 3.82 [FM]	41.14± 3.29 [FM]
Igbigbi and Ebite et al [12]	Malawian	94.35 [M], 96.03 [FM]	Megaseme	-	-
R=right, L=Left, M=Male, FM=Female					

Developmental evidence[1]

Bones of orbit are formed by mesenchymal condensation. At birth, neurocranium is proportionately larger than the viscerocranium. Bones of viscerocranium are relatively small. Because nasal cavity is small and the paranasal air sinuses were in rudimentary condition. Orbital bones are articulated by sutures. At birth the height and width will be equal [13]. Later the width grows more. Development of orbital bones occurs by two types of growth at the sutures and appositional growth. Growth in the skull bones is controlled by molecular signaling system (in the neural crest–mesoderm interface) and intercellular signaling system [1].It includes transcription factor TWIST [14], fibroblast growth factors (FGFs) and fibroblast growth factors receptors (FGFRs) [1]. It is essential for cell proliferation and osteogenic differentiation [15]. Mutations [16] in the genes encoding the specific protein will finally result with premature fusion of the sutures (craniosynostosis). Continuation of Growth at multiple sutures will increase the dimensions in fronto-occipital plane (antero-posterior), transverse plane (breadth) and vertical plane (height) of skull and associated cavities. It occurs in coordinated manner. Growth rate will be more in first year of life. Later it will be slow till seventh year. Growth will complete between 15 to 20years. Growth in metopic suture increases the breadth of the frontal bone. It fuses by 18 months of birth. Formation and development of the frontal and ethmoidal air-cells will cause increase in transverse diameter. The growth at fronto-maxillary suture, fronto-zygomatic suture and development of maxillary sinus will affect the orbital height [17]. In adults orbital base is quadrilateral in shape.

Cranio-Synostosis [1, 16] :

The premature fusion of sutures at the early phase will affect the growth of the facial bones. It produces variability, asymmetry and various abnormalities. It may cause brachycephaly (bilateral sides fails to grow) or plagiocephaly (one side fails to grow). It is also influenced by metabolic disorders, hypophosphatasia. Hence differential growth rate in the bones or sutures in unilateral side will result with variation in the dimensions and asymmetry in orbit and skull. The study [9] has stated that Considerable or clear variation in the growth rate will be displayed in the orbit.

Applied anatomy

The dimensions of orbital base, orbit and skull are useful in the following aspects.

1. Early detection of orbital pathology [18]. Alterations or abnormal widening of orbit will be resulted by bone lesion or increase in intraorbital pressure. It is rapid in child (1-3months), and results in asymmetry in orbital diameters with

erosion or bone destruction. E.g. Tumors of lacrimal gland or benign and malignant tumors.
2. Traumatic disorders [1]: Fracture of orbital base or wall affects the vision. It may produce strabismus or squints, diplopia (double vision) by affecting binocular vision and conjugate movements of eyeball. Fractures in the upper third or middle third of face will affect orbit or its margins. Fracture of frontal bone or maxilla will damage oblique muscles of eye
3. Congenital disorders: Incomplete orbit is one of feature in Mandibulofacial dysostosis [1] (Treacher Collins syndrome) which is congenital anomalies of facial development caused by haploinsufficiency of the gene TCOF1. Dimensions and shape of orbit gives idea about degree of asymmetry.
4. In designing and determining size of the bridge and frame of spectacle and of protective equipment for the eye [19].
5. In the cranial or orbital reconstruction cosmetic surgeries [20] and to avoid surgical complications [7].
6. The biological and personal identity of [1] an individual. (e.g. race, gender, age).
7. Facial approximation (reconstruction) to establish personal identity during forensic investigation.

Clinical significance

Study on dimensions of orbit is important in anatomy, anthropology, forensic science, oral and maxillofacial surgery [8], during reconstruction surgery [20] of orbit and cranium and to avoid neurovascular damage [5]. It is needed for in designing the bridge and frame of spectacle and protective equipment for the eye [19] and head.

CONCLUSION:

Even though the pair of orbital base appears proportionately equal in a skull, they will have difference in dimensions. Each pair of orbits exhibited strong linear relationship between them. Study also recorded that variation and different categories can be found within the same population or race.

Limitations of study

The age and gender wise category is not done. Radiographs were not studied. Further more study on Indian population is recommended.

ACKNOWLEDGEMENTS: The authors are grateful to researchers and authors of the studies and text books cited in the references section of this article. Authors gratefully acknowledge all the authorities of institution, members of teaching, non-teaching staff and all the students for extending valuable support, guidance and cooperation. Authors wish to thank Miss. Anjuka T for photographing the Norma frontalis.

REFERENCES

1. Standring S; Gray's Anatomy, The anatomical basis of clinical practice, 40th edition. Churchill livingstone, Elsevier. 2008.
2. Patnaik VVG, Sangu B, Singla RK; Anatomy of the Bony Orbit- Some Applied Aspects. J Anat. Soc. India, 2001; 50(1): 59-67.
3. Carol E Osborn. Basic Statistics for heath information management technology. Johnes and Bartlett publications, Inc. Sudbury, Massachusetts. 2008
4. Gerstman BB; Basic Biostatistics: Statistics for public health practice. Johnes and Bartlett publications, Inc. Sudbury, Massachusetts, 2008.
5. Fetouh FA, Mandour D; Morphometric analysis of the orbit in adult Egyptian skulls and its surgical relevance. Eur. J. Anat, 2014;18(4):303-315.
6. Kaur J, Yadav S, Sing Z; Orbital dimensions- A direct measurement study using dry skulls. J. Acad. Indus. Res. 2012; 1(6) 293-295.
7. Gosavi SN, Jadhav SD, Zambre BR; A study of orbital morphometry in Indian dry skulls. Asian Journal of Biomedical and Pharmaceutical Sciences, 2014;4(29):23-25.
8. Ebeye O.A, Otikpo O; Orbital Index in Urhobos of Nigeria. IOSR Journal of Dental and Medical Sciences, 2013; 8(2): 51-53.
9. Xing S, Gibbon V, Clarke R, Liu W; Geometric morphometric analyses of orbit shape in Asian, African, and European human populations. Anthropological Science. 2013; 121(1):1–11.
10. Ezeuko CV, Aligwekwe AU, Udemezue OO, Ejimofor OC; Orbit Dimensions and Bony Inter orbital Distance in Southeast Nigerians: A Radiologic Study: J Expt & Clin Ana, 2007; 6:47-50.
11. Leko BJ, Douglas P, Ukoima HS, Madugba C; Radiological Assessment of Orbital Dimensions of the Kalabaris and Ikwerres of Rivers State, Nigeria. African Journal of Biomedical Research, 2012; 15(3):197-200.
12. Igbigbi PS, Ebite LE; Orbital index of adult Malawians. Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology, 2010; 11(1).
13. Howale DS, Jain LK, Iyer K, Lekharu R; Orbital & nasal indices of maharashtra region: a direct measurement study Using dry skulls. International Journal of Current Research.2012; Vol-4 :(8),158-161.
14. El Ghouzzi V, Le Merrer M, Perrin Schmitt F, Lajeunie E, Benit P, Renier D et al;. Mutations of the TWIST gene in the Saethre Chotzen syndrome. Nat Genet, 1997; 15:42-46.
15. Lattanzi W, Bukvic N, Barba M, Tamburrini G, Bernardini C, Michetti F, Di Rocco C; Genetic basis of single suture synostoses: genes,chromosomes and clinical implications. Childs nerv syst, 2012;28(9):1301-1310.
16. Morriss Kay GM, Wilkie AO; Growth of the normal skull vault and its alteration in

craniosynostosis: insights from human genetics and experimental studies. Journal of Anatomy, 2005; 207(5):637-653.
17. Haas A, Weiglein A, Faschinger C, Müllner K; Fetal development of the human orbit. Graefe's archive for clinical and experimental ophthalmology, 1993; 231(4):217-220.
18. Moreiras JVP, Preda MC, Pumar JM; Orbit . Examination, Diagnosis, Microsurgery, Pathology. vol-1. Highlights of ophthalmology international city knowledge, panama. English edition 2004; 73-74.
19. Weaver AA, Loftis KI, Tan JC, Duma SM, Stitzel JD; CT scan based three-dimensional measurement of orbit and eye anthropometry. IOVS, 2010; 51(10): 4892-7.
20. Munguti J, Mandela P, Butt F; Referencing orbital measures for surgical and cosmetic procedures. Ant J of Africa, 2012; 1(1): 40-45.