International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Morphometric Evaluation of Orbital Dimensions and Orbital Index in Adult Dry Human Skulls of Western India: A Descriptive Osteometric Study

Miss. Sukanya Nanaso Gade[1], Dr. Vidya Shankarrao Kharat[2], Dr. Shweta Shankarrao Thorat[3]

[1]Tutor- Anatomy, Bharati Vidyapeeth Deemed to be University, Medical college, Pune
[2]Professor – Anatomy, Bharati Vidyapeeth Deemed to be University, Medical college, Pune
[3]Associate Professor – Anatomy, Bharati Vidyapeeth Deemed to be University, Medical college, Pune

OPEN ACCESS

Corresponding Author:

Dr. Shweta Shankarrao Thorat
Associate Professor – Anatomy, Bharati Vidyapeeth Deemed to be University, Medical college, Pune

Received: 04-12-2025
Accepted: 23-12-2025
Available online: 31-12-2025

ABSTRACT

Background: The orbit is a complex bony cavity essential for ocular function and protection. Variations in orbital dimensions across populations are influenced by genetic, ethnic, and regional factors. The orbital index (OI) serves as an anthropometric parameter to classify orbits and is valuable in forensic, anatomical, and surgical applications. Despite India's vast population diversity, limited region-specific morphometric data are available for the western Indian population.
Aim: To evaluate the orbital dimensions and orbital index in adult dry human skulls from Western India, and to classify orbital types based on the orbital index.
Materials and Methods: A descriptive osteometric study was conducted on 60 adult dry human skulls obtained from Anatomy departments of Medical colleges in Pune, Maharashtra. Orbital height, breadth, and perimeter were measured bilaterally using Vernier calipers and flexible thread. The orbital index was calculated as (orbital height/orbital breadth) × 100. Orbits were categorized into microseme (OI $\leq$ 83), mesoseme (OI 84–88.9), and megaseme (OI $\geq$ 89). Statistical analysis included descriptive statistics and paired t-tests.
Results: The mean orbital height was 31.37 ± 2.08 mm, and the mean orbital breadth was 38.79 ± 2.22 mm. The orbital index averaged 81.09 ± 6.81, with most orbits (63.33%) falling into the microseme category. The orbital breadth differed significantly between right and left orbits ($p = 0.00$), while height and perimeter showed no statistically significant side differences. The mean orbital perimeter was 128.04 ± 8.45 mm.
Conclusions: This study provides normative morphometric data for the Western Indian population, showing a predominance of microseme orbital type. The results underscore the need for region-specific orbital data for use in Anatomy, forensic identification, and clinical surgical planning.

***Keywords**: Orbital index, orbital morphometry, dry skull, microseme, Western India, orbital dimensions*

INTRODCUTION

The orbit is a four-sided pyramid-shaped bony cavity of the skull, which contains the eye ball, muscles and nerves of the eye, and the lacrimal apparatus [1]. The eyeball should be well protected and the eye itself should have normal function both depend on the integrity of the avascular orbit. Orbits are the most emphatic element of the facial skeleton. [2] Orbits are intricate because it is made up of several bones and which has fissures, foramina, and canals. [3] The orbit is an important landmark in anatomy as it lies at the junction of the central nervous system and is connected with the face, nose, paranasal sinuses. [4]. Researchers have given considerable attention to the orbit, primarily focusing their work on modern mammals. [5]. Entered by an evolutionary historian: Morphology of the orbit has evolved as an adapted feature and features greater variation across species [6,7]. From a clinical perspective, the size and shape of the orbit are of paramount importance, accurate orbital measurements are essential for ophthalmology, neurosurgery, and maxillofacial surgery to treat trauma, and congenital craniofacial anomaly [8.9]. The information is also beneficial for facial reconstructive surgeries and plays a role in the clinical assessment of Down syndrome. [10] Its extensive and successful application in anthropology includes human identification, particularly in scenarios like natural disasters and accidents where remains are mutilated or fragmentary. [11] It can also help to understand and trace the migration routes of early civilization [12] Normative orbital data is used by Surgeons to plan the repair of orbital fractures and deformities in a clinical context, highlighting the applied nature of orbital morphometry [13].

An important factor in these studies is the orbital index (OI) – which is calculated as the orbital height (vertical diameter) divided by the orbital breadth (horizontal diameter) multiplied by 100 [14]. As the orbit index (OI) differs significantly with ancestry and geographic nationality [15], it has been historically utilized to divide orbital pattern into microseme, mesoseme, and megaseme. Microseme OIs are small (OI 89) [14,15]. Early anthropologists compared these categories to large racial types - originally African skulls were 'microseme', European were 'mesoseme' and East Asian were 'megaseme' [14,15]. While these racial types are historical, the orbital index is still valuable for expressing variation among populations.

This also has forensic importance, as orbital measurements (including OI) can help determine the racial affinity of a skeleton in a forensic case [16]. Furthermore, orbital measurements in detail offer reference data for comparative anatomy. In reconstructive orbital surgery, for example, the knowledge of orbital dimensions is of utmost importance supporting the surgeon to restore the orbital frame as well as its symmetry especially in trauma patients or for the design of an orbital implant [17].

A large ethnic and regional diversity in India makes it essential to study the orbital morphology in the Indian population. A few osteometrics studies documented orbital dimensions among various Indian sub-populations [6,18].

In general, these studies revealed that the Indian skull has a low orbital index, falling in the microseme category [6]. For instance, the average values of OI for western Indian (Maharashtrian) skulls were in low 80's which made these orbits microseme [6]. However, regional variations exist. Higher OI values have been reported from studies in southern India; an investigation of skulls from the coast of Andhra Pradesh had mean OI values in the higher 80's (borderline mesoseme) [14]. These discrepancies emphasize the necessity of examining the orbital parameters within a given community or location. Indeed, the lack of regional orbital data in some areas of India has been highlighted by previous authors [19].

Several orbital measurements such as the orbital perimeter may have possible implications both for clinical and anthropological studies and these are not frequently documented in the literature [20].

In view of the above, the aim of the present study was to study the orbital morphology in adult dry human skulls of Indian population (Western India). This regional data will enhance our anthropometric knowledge of orbital variability and serve as baseline comparison for Anatomy, forensic identification and clinical work.

Aim of the Study: To measure the orbits (orbital height, breadth, and perimeter and orbital index) in adult dry human skulls of an Indian population and determine the side differences.

Objectives

- To compare and analyze the morphometric measurements of the right and left orbital cavities in adult dry skulls.
- To study the bilateral symmetry of orbit providing a baseline of morphometric measurements for ophthalmic surgeons, plastic surgeons as well as maxillofacial surgeons.

MATERIALS AND METHODS

This was a descriptive cross-sectional study conducted in the Department of Anatomy at multiple Medical colleges in Pune, India. The study focused on the morphometric evaluation of orbital cavities in adult dry human skulls.

Prior to the initiation of the study, ethical clearance was obtained from the Institutional Ethics Committee (BVDUMC/IEC/76). Permissions were also secured from the authorities of the participating Medical colleges for access to the osteological collections.

A total of **60 adult dry human skulls** of unknown sex and age, but fully ossified and free from visible deformities or damage in the orbital region, were included in the study. Skulls exhibiting fractures or gross deformities in the orbital region were excluded.

Materials and Instruments:

The following tools were used for data collection: Vernier calipers (for linear measurements), Nylon thread and scale (for curved perimeter measurement), Measuring thread (for tracing the orbital rim) as seen in figure-1

Parameters Measured

The following morphometric parameters were studied for each orbit (right and left):

- **Orbital Height (Length)** – the maximum vertical distance between the superior and inferior orbital margins, as seen in figure 2
- **Orbital Breadth (Width)** – the maximum horizontal distance between the medial and lateral orbital margins, as seen in figure 3
- **Orbital Perimeter** – the circumferential measurement of the bony orbital rim using nylon thread, as seen in figure 4
- **Orbital Index (OI)** – calculated as:

$$\text{Orbital Index} = \left(\frac{\text{Orbital Height}}{\text{Orbital Breadth}}\right) \times 100$$

Based on the OI, orbits were classified into three categories: **Microseme** (OI ≤ 83), **Mesoseme** (OI = 84–88.9), and **Megaseme** (OI ≥ 89)

Data Collection and Measurement Technique
All measurements were taken bilaterally (right and left orbits) using standard anthropometric techniques. **Linear measurements** (height and breadth) were taken with Vernier calipers to the nearest 0.01 mm. **Orbital perimeter** was traced with nylon thread along the bony margin of the orbital rim and then measured using a millimeter scale. Each parameter was measured independently by two observers to minimize inter-observer bias, and the mean value was used for analysis.

Data were compiled in Microsoft Excel and analyzed using descriptive and inferential statistical methods. Mean and standard deviation were calculated for each parameter. The paired t-test was used to compare right and left side values, and a *p*-value < 0.05 was considered statistically significant.

RESULTS
In the present study total of 60 human dry skulls. The statistical analysis of all the parameters was done by using t-test, to compare the quantitative morphometry of the orbital cavity. Corresponding and opposite side parameters have been compared.

Orbital Length / Height: The mean length of the right and left orbits was found to be similar. The overall mean and standard deviation of orbital height was 31.37 ± 2.08 mm. When assessed individually, the mean orbital height of the right and left orbital cavities measured 31.34 ± 2.07 mm and 31.40 ± 2.07 mm, respectively. The difference between the orbital lengths on the right and left sides was not statistically significant. (Table 1)

Table 1: Orbital height/ Length

Length	Mean (mm)	SD(mm)	P-Value
Right	31.34	2.07	0.61
Left	31.40	2.07	
Average	31.37	2.08	

Orbital Breadth Measurement: The orbital breadth of the right and left orbits was not similar, with the right orbit showing a slightly larger breadth compared to the left. The overall mean and standard deviation of orbital breadth was 38.79 ± 2.22 mm. Specifically, the mean orbital breadth of the right and left orbital cavities measured 39.03 ± 2.35 mm and 38.56 ± 2.09 mm, respectively. This difference in breadth between the two sides was statistically significant (p = 0.00). (Table 2)

Table 02: Orbital Breadth

Breadth	Mean (mm)	SD(mm)	P-Value
Right	39.03	2.35	**0.00**
Left	38.56	2.09	
Average	38.79	2.22	

Orbital Index: The mean and standard deviation of the orbital index was 81.09 ± 6.81 mm. The mean orbital index of the right and left orbital cavities measured 80.57 ± 7.23 mm and 81.60 ± 6.37 mm, respectively. Since the mean orbital index for both sides was ≤ 83, the orbits were classified under the microseme category, which is characteristic of smaller orbital height relative to breadth. In this study, 63.33% of the orbital cavities were classified as microseme, 24.17% as mesoseme, and 12.50% as megaseme. The variation in orbital index among the skulls showed statistical significance. (Table 3)

Table 3: Orbital Index

Orbital Index	Mean (mm)	SD(mm)	P-Value
Right	80.57	7.23	**0.05**
Left	81.60	6.37	
Average	81.09	6.81	

Classification of the Orbital Cavities According to Orbital Index in Adult Dry Human Skulls: Based on the classification of the orbital cavity according to the orbital index, a total of 120 orbits (60 skulls, both sides) were analysed. Among these, 76 orbits (63.33%) were categorized as microseme (orbital index ≤ 83), with 40 orbits (66.67%) on the right side and 36 orbits (60.00%) on the left. A total of 29 orbits (24.17%) were classified as mesoseme (orbital index between 83 and 89), comprising 12 orbits (20.00%) on the right and 17 orbits (28.33%) on the left. The remaining 15 orbits (12.50%) were classified as megaseme (orbital index ≥ 89), including 8 orbits (13.33%) on the right and 7 orbits (11.67%) on the left. (Table 4). This distribution highlights a predominance of the microseme type in the studied Indian population.

Table 4: Classification of the orbital cavity according to orbital index in dry skulls.

Classification of the orbital cavity according to orbital index	Total		Right		Left	
	No.	%	No.	%	No.	%
Microseme (OI<=83)	76	63.33	40	66.67	36	60.00
Mesoseme (OI 83 to 89)	29	24.17	12	20.00	17	28.33
Megaseme (OI >=89)	15	12.50	8	13.33	7	11.67
Total	**120**	**100.00**	**60**	**100.00**	**60**	**100.00**

Perimeter Orbit: The perimeter of the right and left orbital cavities was not similar, with slight variation observed between the two sides. The overall mean and standard deviation of the orbital perimeter was 128.04 ± 8.45 mm. Specifically, the mean perimeter of the right orbital cavities was 127.69 ± 8.37 mm, while that of the left orbital cavities was 128.39 ± 8.52 mm. However, this difference in orbital perimeter between the right and left sides was not statistically significant. (Table 5)

Table 5: Perimeter Orbit

Perimeter Orbit	Mean (mm)	SD(mm)	P-Value
Right	127.69	8.37	0.26
Left	128.39	8.52	
Average	128.04	8.45	

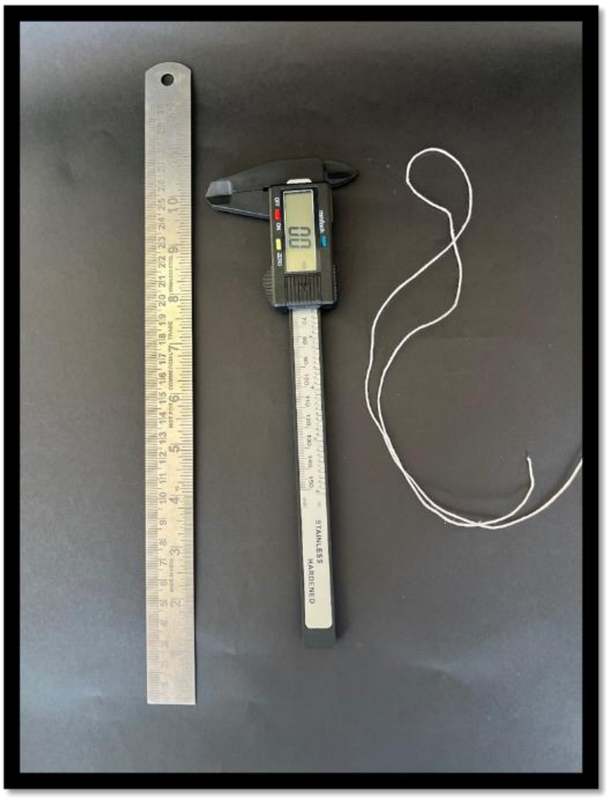

Figure 1: Instruments

Figure 2 : Orbital Height(length) measurement

Figure 3 : Orbital Breadth (Width) measurement

Figure 4: Orbital Perimeter

DISCUSSION

The present morphometric analysis of the orbital cavity in adult dry human skulls from Western India offers critical insights into regional orbital architecture. Parameters studied included orbital height, breadth, perimeter, and the calculated orbital index. These findings are significant in the context of anatomical variation across different ethnic and geographical populations, and they contribute valuable normative data for forensic anthropology, reconstructive surgery, and comparative anatomy.

Orbital Height: The average orbital height for our study was 31.37 ± 2.08 mm. This is consistent with the value reported by Amjad et al. who found orbital height as 31.50 ± 2.40 mm in Maharashtrian skulls [6]. Gosavi et al. also recorded similar size (32.1 ± 2.5 mm) on Indian dry skulls of unknown region [18]. Rao et al. recorded a mean OPH of 33.2 ± 2.1 mm in skulls from coastal Andhra Pradesh, suggesting regional population specificity with a regional trend in southern India of vertically elongated orbits [14].

International studies, in contrast, demonstrated higher orbital heights. Ukoha et al. in a Nigerian adult male population observed an orbit height of 34.5 ± 2.8 mm [13] and in another a mean orbit height of 34.5 mm with a standard deviation of 2.8 mm [16]. These higher values suggest craniofacial architectural differences shaped by ethnic and evolutionary influences.

Orbital Breadth: Our measurements showed that the average orbital width was 38.79 ± 2.22mm, and there was a significant difference between two orbits (p = 0.00). Amjad et al. also obtained akin values. (38.80 ± 2.10 mm) [6] and to Gosavi et al. (38.7 ± 2.6 mm) [18]. In the Andhra population, however, Rao et al. reported a little greater width (39.4 ± 1.9 mm) [14]. For international populations, the mean width is slightly different: Ukoha et al. reported a width of 39.0±2.4 mm [13], while Khan et al. reported 40.1 ± 2.9 mm in Pakistani skulls [16]; however, this indicates that the orbital cavity should be slightly wider in non-Indian populations.

Interestingly, our study showed significant asymmetry between right and left orbit breadths, a pattern also documented by Subbulakshmi in Tamil Nadu skulls [8]. This might reflect developmental or functional asymmetries and highlights the importance of considering side differences in both anatomical teaching and surgical planning.

Orbital Index and Population Classification: Orbital Index (OI), a significant anthropometric landmark, was derived as the index of orbital height to breadth × 100. The mean OI was 81.09 ± 6.81 in this study, which classified most skulls (63.33%) as microseme (OI ≤ 83). This finding corroborates the results of Amjad et al., who also classified Maharashtrian skulls mainly as microseme (mean OI: 81.27 ± 4.11) [6].

Higher indices were reported in other Indian studies: Gosavi et al, observed a mean OI 83.27 ± 6.71 [18] and Rao et al. of Andhra Pradesh was found to be 84.3 ± 4.62 [14], suggestive of a mesoseme trend in the southern Indian population. Alam et al. also obtained a mesoseme when classifying OI as 85.2 ± 4.3 in the cranial data of Northern India. [15]. This internal variations within India underscores the need for region-specific anthropometric data.

Comparatively, non-Indian populations displayed a higher prevalence of mesoseme and megaseme types. Ukoha et al. reported an OI of 88.5 ± 6.2 (predominantly megaseme) in Nigerian skulls [13], and Khan et al. found an OI of 85.1 ± 5.8

(mesoseme) in a Pakistani population [16]. These differences further reinforce the role of ancestry and geographic lineage in determining craniofacial features.

Orbital Perimeter: The perimeter of the orbit, a less commonly reported metric, was 128.04 ± 8.45 mm in our study, with right and left perimeters measuring 127.69 ± 8.37 mm and 128.39 ± 8.52 mm respectively. The difference was not statistically significant (p = 0.26). This observation aligns with Khan et al., who emphasized the importance of perimeter values in reconstructive surgical planning [16]. Yildiz et al. also highlighted orbital perimeter as a relevant metric in population studies, though data remains scarce in Indian populations [21].

The consistency of orbital perimeter bilaterally suggests symmetrical rim development, in contrast with the notable asymmetry in breadth. These findings may have important implications for prosthesis fitting and surgical interventions involving the orbital rim.

Our results underscore the variation in orbital dimensions and classification not only across ethnicities but also within different Indian sub-regions. While the present Western Indian sample predominantly exhibited microseme features, mesoseme characteristics are more common in southern and northern populations, reflecting craniofacial diversity shaped by both genetic and environmental factors.

CONCLUSIONS

The present study provides region-specific normative data on orbital morphometry in adult dry human skulls from Western India. The mean orbital height was found to be 31.37 ± 2.08 mm, and the mean orbital breadth was 38.79 ± 2.22 mm. The orbital index averaged 81.09 ± 6.81, classifying the majority of orbits as microseme. A statistically significant difference was observed in orbital breadth between the right and left sides, whereas orbital height and perimeter showed no significant side-to-side variation. The perimeter of the orbit was found to be 128.04 ± 8.45 mm on average.

These findings are in agreement with previous studies conducted on Maharashtrian and general Indian populations and support the presence of ethnic and regional variation in orbital morphology. The predominance of the microseme type in this population adds to the anthropometric mapping of the Indian subcontinent and provides a useful baseline for forensic anthropologists, ophthalmic surgeons, and anatomists.

LIMITATIONS

Sample Size and Regional Scope: The study was limited to 60 skulls from Western India, which may not comprehensively represent the entire Indian population. Broader regional representation could enhance generalizability.
Manual Measurement Method: Measurements were taken manually using calipers and threads, which may introduce minor observer-dependent variability despite efforts to reduce bias. Use of digital imaging or CT scanning could improve precision.

Conflict of Interest: None to Declare
Sources of Funding: None

REFERENCES

1. Standring S, editor. Gray's Anatomy e-Book: The Anatomical Basis of Clinical Practice Elsevier Health Sciences, 2021, May 22: 666-7
2. Novita M. Facial, upper facial, and orbital index in Batak, Klaten, and Flores students of Jember University. Dental Journal (MajalahKedokteran Gigi). 2006 Sep 1;39(3):116-9.
3. Ezeuko VC, Om'Iniabohs FA. Radiologic evaluation of the orbital index among the Igbo ethnic group of Nigeria. Eur j anat. 2015;19:9-14.
4. Weisman, RA. Surgical anatomy of the orbit. OtolaryngolClin North Am 1988; 21: 1–12
5. Lautenschlager S. Functional and ecomorphological evolution of orbit shape in mesozoic archosaurs is driven by body size and diet. Commun Biol. 2022 Aug 11;5(1):754. doi: 10.1038/s42003-022-03706-0. PMID: 35953708; PMCID: PMC9372157.
6. Amjad S, Riyaz ZH, Siddiqui AA, Ansari MDK. Orbital dimensions of the Maharashtrian population: a direct measurement study using dry skulls. Int Dent J Stud Res. 2019. Available from: https://www.academia.edu/download/97280700/10611.pdf
7. Ghosh A, Manjari C, Mahapatra S. The craniofacial anthropometric measurement in a population of normal newborns of Kolkata. Nepal J Med Sci. 2013. Available from: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c268ca1f644d266d6654054b0a10e4de1b4080d7
8. Subbulakshmi A. Morphometric study of the orbit in human dry skulls and high-resolution computed tomographic scans [dissertation]. Tamil Nadu: The Tamil Nadu Dr. MGR Medical University; 2017. Available from: http://repository-tnmgrmu.ac.in/id/eprint/4849
9. Nitek S, Wysocki J, Reymond J, Piasecki K. Correlations between selected parameters of the human skull and orbit. Med Sci Monit. 2009;15(10):CR510–CR517.

10. Patnaik VVG, Bala S, Singla R K. Anatomy of bony orbitsome applied aspects. J Anat Soc India. 2001; 50(1):59-67.
11. Oldaipo GS, Olotu JE, Suleiman Y. Anthropometric studies of cephalic indices of the Ogonis in Nigeria. Asian J Med Sci. 2009; 1:15-7.
12. Sah, Mr & Yadav, Dr. (2024). A morphometric analysis of orbit in dry adult human skulls and its clinical importance. Journal of Population Therapeutics and Clinical Pharmacology. 10.53555/jptcp.v31i3.5111.
13. Ukoha U, Egwu OA, Okafor IJ, Ogugua PC, Onwudinjo O, Udemezue O. Orbital dimensions of adult male Nigerians: a direct measurement study using dry skulls. Int J Biol Med Res. 2011;2(3):688–90. Available from: https://www.academia.edu/download/72858751/Orbital_dimensions_of_adult_male_nigeria20211016-12340-1o6byoq.pdf
14. Rao N, Pramila Padmini M. A study of orbital index in dry skulls of North Coastal Andhra Pradesh. Int J Basic Appl Med Sci. 2014;5(2):1–3. Available from: https://www.researchgate.net/publication/281426687
15. Alam MT. Orbital dimensions and orbital index of adult human dry skull: a direct measurements study. 2014. Available from: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=+Alam+M.+T.+orbital+dimensions+and+orbital+index+of+adult+human+dry+skull+a+direct+measurements+study
16. Khan H, Khan Z, Nadeem G, Khair AMB. An anatomical study of orbital dimensions and its utility in orbital reconstructive surgery. Onkol Radioter. 2021;15(4):25–30. Available from: https://www.researchgate.net/publication/351972633
17. Garg R, Muneer A. Morphometric study to assess dimensions of orbital roof and floor in dry skulls. J Clin Diagn Res. 2020. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/sea-203564
18. Gosavi SN, Jadhav SS, Zambre BR. A study of orbital morphometry in Indian dry skulls. Int J Basic Appl Med Sci. 2014;4(1):64–68. Available from: https://www.researchgate.net/publication/261988016
19. Nagaraj S, Prabha V, Jayaram S, Ramesh D, Kumari S, Jaiswal A, et al. Orbital morphology of Telangana region: a direct measurement study. Int J Approx Reason. 2017;5:3354–3357.
20. Shukla A, Bokariya P, Kothari R, Agrawal A, Ninama R, Nema RK, et al. Measurement of orbital dimensions (orbital height, breadth, and length of superior orbital fissure) using dry skulls. Delhi J Ophthalmol. 2020;30(1):10–14. Available from: https://journals.lww.com/djo/abstract/2020/31010/measurement_of_orbital_dimensions__orbital_height,.10.aspx
21. BV S, KV V. Study of orbital morphometry in dry skulls of South Indian origin. Int J Curr Res Rev. 2018. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/sea-198345