Original Article

Assessment of Human Orbital Index and Mandible in Gender Determination: An Institutional-Based Retrospective Cone-Beam Computed Tomographic Study

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Abstract

Background and Aim: Gender determination of bone is a very important part of study in anthropology and forensic science. This osteometric study helps in establishing the process of evolution, race, and demographic profile. If gender is determined first, then further investigations such as estimation of both age and stature can be confirmed with ease. Thus, the present study aims to assess the reliability of human orbital index (OI) and mandible in gender determination using cone-beam computed tomography (CBCT).

Materials and Methods: A total of 60 CBCT images obtained using Planmeca Proma × 3D Mid Pro Face machine, taken for the purpose of various dental treatments for the patients with the age group of 10–60 years. Various parameters such as OI (maximum vertical distance of the orbital cavity/maximum horizontal distance of orbital cavity × 100) and in mandible (gonial angle and intercondylar distance) were measured using Romexis software.

Results: OI showed an increase with age up to 40 years and then there was a decline with further increase in age. Gonial angle – the mean range of gonial angle values was recorded for females is 119.56–129.08 and for males 112.33–123.68 and also shows positive correlation being observed between gonial angle and age in both the sexes. Intercondylar increases with increase in age and did not exhibits much of difference between the males and females and furthermore between both the sides.

Conclusion: Identification of gender from available skeletal remains is of great medicolegal significance. Thus, the present study will clearly express if morphometric analysis of orbit and mandible will be one of the reliable parameters for gender determination.

Key Words: *Cone-beam computed tomography, forensic science, mandible, orbital index*

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Introduction

Forensic odontology is the application of dental principles to legal issues.[1] It is an investigatory aspect of dentistry which includes proper handling, examination, and evaluation of dental evidence, which will be presented in the interest of justice.[2] Forensic odontology has three vital steps in identification, i.e. gender determination, age estimation, and personal identification. Gender determination becomes the first priority in the process of identification of a person by a forensic investigator in the case of mishaps, chemical and nuclear bomb explosions, natural disasters, crime investigations, and ethnic studies.

Sex determination analysis can be done either by morphological analysis or by molecular analysis. Morphological analysis can be done on hard tissues of oral (odontometric and orthometric) and paraoral regions or soft tissue (lip prints – cheiloscopy, palatal rugae pattern – rugoscopy).

Among human bones, the pelvis and skull are the most reliable source for sex determination.[3] In the absence of complete pelvis, then mandible and human orbit becomes important source of value for anthropology and for tracing population origins, gaining insight into craniofacial growth due to racial and sexual differences, quantifying intraspecific variations and forensic osteology.[4] The mandible bone which forms the lower jaw plays an indispensible role in determining an individual's facial features.[5] Various parameters in the mandible can be considered as a valuable tool in gender determination since it possesses resistance to damage and disintegration processes. The presence of a dense layer of compact bone makes it very much durable and well preserved than any other bones.

The human orbit is a complex anatomic region. Each of its four bony walls has its own unique features and is

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perforated by a number of fissures and foramina that carry important nerves and blood vessels.[6] One well-utilized parameter of orbital morphology is the orbital index (OI) which is defined as a ratio between the orbital height to its width. The use of this parameter is favored for several reasons:

(1) Standardized and can be measured in the living and deceased, (2) measurement is rapid and trivial, and (3) race- and sex-specific database can be possibly.[7]

Forensic radiology encompasses the acquisition, interpretation, and reporting of radiologic images for the purpose of medicolegal investigations.[8] Most of the modalities commonly employed in clinical imaging can also be applied to forensic cases, such as lateral oblique radiographs, cephalometric radiographs, digital panoramic imaging, and advanced imaging technologies such as cone-beam computed Tomography (CBCT).

Introduction of CBCT to imaging of the maxillofacial region led to a true shift from 2D to 3D approach. The CBCT machine uses cone-beam imaging technology and provides a complete 3D view of the maxilla, mandible, teeth, and supporting structures with relatively higher spatial resolution and lower radiation dose to the patient. Data are acquiescent to reformation in a volume, rather than a slice, providing 3D information with minimal distortion, and it is highly useful as it has become an indispensable part of the dental imaging armamentarium.

This study utilizes CBCT for the evaluation of OI and mandibular parameters such as gonial angle and intercondylar distance for in the determination of gender.

Aim and Objectives

The aim of the study was to assess the reliability of osteometric measurements of human OI and mandible in determination of gender using CBCT.

- To estimate and infer various osteometric measurements of human orbit and mandible
- To evaluate and compare the accuracy of these anthropometric measurements in determination of gender.

Materials and Methods

A retrospective study carried out in the Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and Hospital, Chennai. The study population of sixty CBCT images which were collected from the department database from the age ranges from 10 to 60 years, out of which thirty were males and thirty were females. The ages were further grouped into (Group I–Group V). Each group contains 12 CBCT images, and group interval was 10 years. All the images were recorded in Planmeca Promax 3D Mid Pro Face machine and were processed using Planmeca Romexis software.

Inclusion criteria

Full skull CBCT images were included.

Exclusion criteria

Facial surgeries or severe trauma, developmental disturbance or pathologic condition, or distorted image were excluded.

Parameters included in the study are (a) OI, (b) gonial angle, and (c) intercondylar distance.

Orbital index

- Orbital height – Highest distance between the superior and inferior orbital margins [Figures 1a and c]
- Orbital width – Maximum lateral curved distance between the medial margin and the lateral margins of the orbit [Figure 1b].

$$\text{OI} = \frac{\text{Orbital height}}{\text{Orbital width}} \times 100$$

Gonial angle

Intersection of Tangential line drawn from distal surface of ramus and other Tangential line drawn from lower border of mandible forms the gonial angle. The intersection of these lines formed the gonial angle [Figure 2].

Intercondylar distance

Distance between the most lateral points on the two condyles [Figure 3].

Results

The results were tabulated and the values were made note of, and the data were subjected for statistical analysis using statistical software SPSS version. 16 (IBM. Corp. Chicago, IL, USA). The data were tested for normality using Shapiro–Wilk test and was found to be parametric in distribution ($P > 0.05$). Confidence intervals were set at 95%, and $P < 0.05$ was considered statistically significant.

Table 1 represents the descriptive analysis comprising mean, standard deviation, and *P* value were calculated for all sample data. The data reveal where mean values of OI right and left, gonial angle for right and left, and intercondylar distance for all group of ages when correlated with gender shows highly statistically significant value.

Orbital index

- Mean horizontal diameter 39.52 mm for right and 37.35 mm for left orbit
- Mean vertical diameter 32.64 mm for right and 32.39 mm for left orbit
- Mean OI was 106.44 ± 5.81 for right and 106.88 ± 6.41 for left
- There was an increase in the OI with age up to 40 years and then there was a decline with further increase in age [Graph 1a and b].

Gonial angle

- The range of gonial angle values were recorded for females is 119.56–129.08 and for males 112.33–123.68
- Positive correlation was observed between gonial angle and age in both the sexes which was due to alterations in the morphology of basal bone of mandible and reduced density and activity of masticatory muscle [Graph 2a and b].

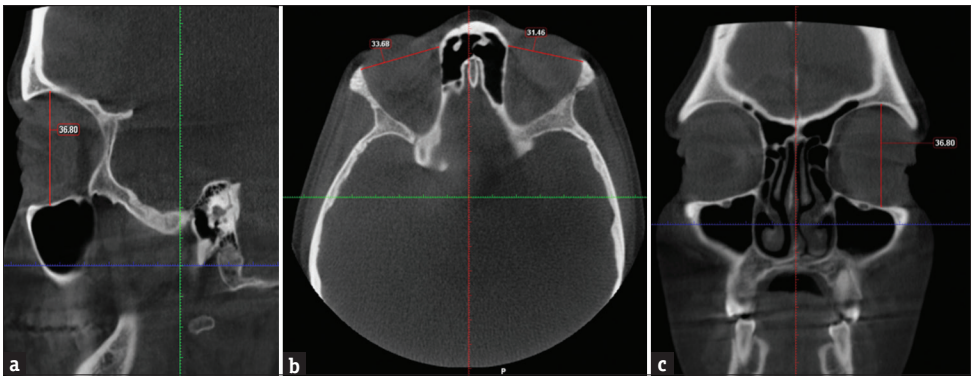


Figure 1: (a) Orbital height measured in sagittal plane. (b) Orbital width measured in axial section. (c) Orbital height measured in coronal plane

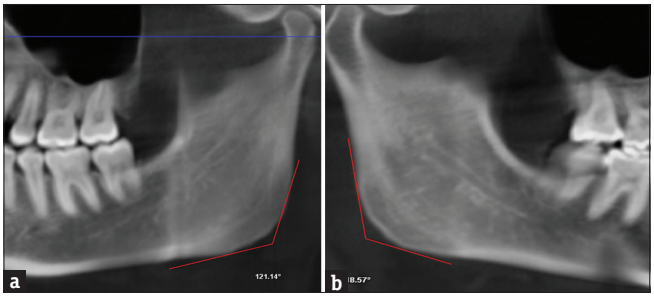


Figure 2: Gonial angle measurement (a) Right and (b) left side Gonial angle measurements

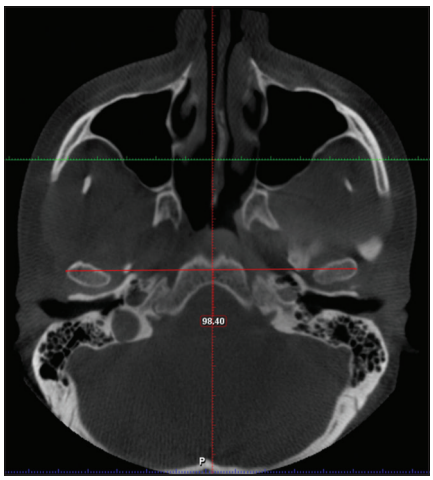
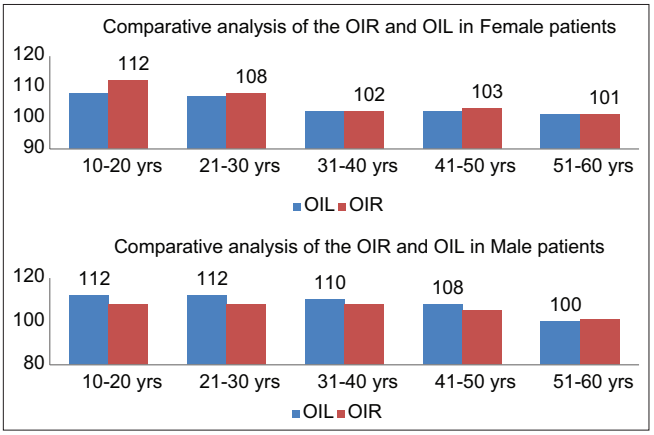


Figure 3: Intercondylar distance measured in axial section



Graph 1: (a) Orbital index of females. (b) Orbital index of males

Intercondylar distance

- The intercondylar distance ranges from 102.96 to 117.54 in males and 106.76 to 112.34 in females
- Intercondylar distance increases with increase in age
- Did not exhibit much of difference between the males and females and furthermore between both the sides [Graph 3a and b].

Discussion

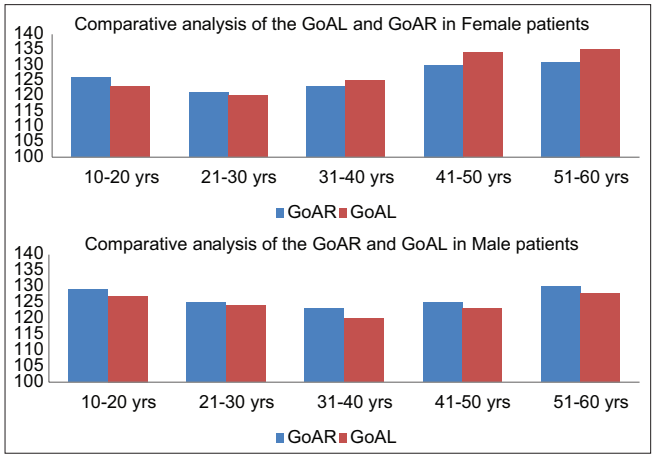
In forensic anthropology, human skeleton plays a major role in determination of sex. Researches have propose two approaches, i.e. nonmetrical (morphological) and metrical for the determination of sexual characteristics from the bones.[9] It is well known that several structures of the skull have the positive potential to identify an individual due to better retention of the morphological features.[10] Orbit is an important anatomical landmark, and morphological variations of the orbital aperture measurements can act as a parameter for sexual and ethnic determination.

The present study demonstrated that the gender difference was significant and that the overall OI was larger in males than in females. However, the maximum width of the orbital aperture showed statistically significant result, whereas height of the orbital aperture showed no statistically significant differences between genders and also showed increase in the OI with a peak attained in the age group of 30–39 years, but then there is a decline of OI with further increase in age. These findings were consistent with that of the study done by Igbigbi and Ebite *et al.*[11] in 2010 in European population and also found to be consistent with that of the study conducted by Nitek *et al.* in 2009[10] who evaluated the orbital aperture width and height in 100 Polish dry human skulls and concluded that these dimensions were larger in males than in females and study conducted by Sangvichien *et al.*[12] in 2007 also found a significant difference in the breadth between the two genders, but his findings related to orbital height showed no significant difference between genders. On the contrary, a study done by Rajangam *et al.*[13,14] in 2012 Indian population using dry skull stated that there was no significant difference in the height and breadth of the orbit between the two genders.

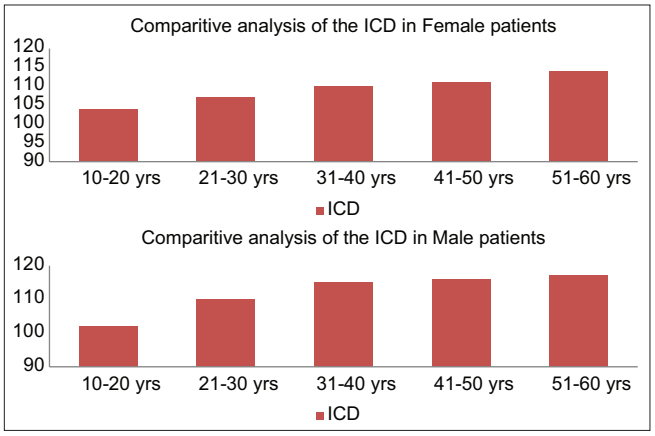
Table 1: Descriptive analysis

Variables		Mean±SD				
Age category (years)	Gender	OWR	OWL	MGAR	MGAL	ICD
10-20	Males	112.33±7.1	108.30±8.41	112.33±7.19	108.30±8.41	102.96±1.74
	Females	108.82±6.38	112.20±5.98	129.08±9.30	127.15±6.27	106.28±6.03
21-30	Males	108.82±6.65	107.38±6.47	121.96±11.7	120.27±6.50	114.08±5.99
	Females	108.25±5.33	112.06±5.51	128.82±9.12	124.99±6.84	107.81±7.35
31-40	Males	102.61±2.63	102.33±5.49	120.05±7.38	125.37±7.74	117.27±3.78
	Females	108.35±6.88	110.02±5.67	123.68±11.2	120.18±4.22	110.40±9.04
41-50	Males	101.88±1.85	101.92±2.84	141.70±3.17	134.26±9.74	113.15±7.02
	Females	105.66±2.28	108.42±4.58	119.56±6.25	120.20±5.60	111.89±2.52
51-60	Males	106.60±5.64	105.85±5.41	123.21±6.34	123.75±5.95	111.46±4.06
	Females	101.50±3.33	100.65±1.45	121.15±9.06	119.52±8.10	114.75±5.52

SD: Standard deviation, OWR-Orbital width right, OWL-Orbital width left, MGAR-Mean gonial angle right, MGAL-Mean gonial angle left, ICD- Intercondylar distance



Graph 2: (a) Gonial angle for females. (b) Gonial angle for males



Graph 3: (a) Intercondylar distance for females. (b) Intercondylar distance for males

Mandible is the most durable and sexually dimorphic bone.[15] As the mandible is the last skull bone to cease growth, it is sensitive to adolescent growth spurt. The stages of mandibular development, growth rates, and its duration are distinctly different in both the sexes and so it becomes particularly useful in differentiating between sexes.[16]

In the present study, gonial angle of females was significantly higher than males and also showed positive correlation between age and gonial angle. This is during growth period; the ramus height increases more than the mandibular body length and so angle becomes acute in children and due to loss of tooth substance as the age advances the gonial angle is obtuse. These findings were in accordance with the study done by Gopal *et al*. in 2018[17] using 100 CBCT images in Indian population stated that the gonial angle becomes obtuse when age advances and also by Kanjani V *et al* and Williams BA *et al,* Rogers *et al*.[18,19] in Orthopantomographic study in 2009 found out there were significant variations in gonial angle of males and females.

The present study reveals that the intercondylar distance increases with increasing in age and did not exhibit much of difference between the males and females and furthermore between both the sides. These findings were in consistent with the study done by Gopal *et al.*[17] in 2018 and Kanjani *et al.*[18] in 2009 did an OPG study to evaluate that there is no existence of any differences in the intercondylar distance among the males and females.

Although it has been established that socioenvironmental factors influence the development, and thus the appearance of bones,[20] researchers have affirmed that the dimensions of orbit and mandible may contribute in clinical, forensic, archaeological contexts, and clinical diagnosis and treatments.

The present study was carried out using 3D CBCT images which revealed a high accuracy rate (95.1%) for sexual prediction, suggesting that such images can be used for effective and accurate anthropometric measurements.

Conclusion

As dental professionals, we can continue to play a key role by maintaining quality records and thus could be a part of the investigating team in the field of forensics. These days CBCT is gaining more popularity over the other conventional radiographic techniques because of lesser radiation exposure, better accuracy thus it could widen frontiers in the field of forensics. One such frontier would be analyzing the OI and mandibular parameters such as gonial angle in gender

determination. Thus, the outcome of the present study proves certain morphometric analysis of orbit and mandible could prove reliable for gender determination.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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