Head neck imaging ORIGINAL ARTICLE

Gender and Aeon morphometric scrutinization of the mandible-A 2D panoramic study

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ABSTRACT

Introduction: Dentofacial radiography is a structured and precise methodology employed in dental, medical, and hospital clinics for diverse purposes in the diagnosis and treatment of orofacial disorders. One such ordinance is the distinction of sexual dimorphism at different ages in the study population. The mandible is the most commonly employed bone for the determination of age and sex in the field of anthropology, planning surgeries, augmentation of grafts, placement of implants, and in forensic science, as it undergoes a lot of morphological transitions due to continuous remodeling.

Materials And Methods: This is an in vitro study appraised in the Department of Oral Medicine and Radiolo-

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gy. 210 OPGs selected by the purposive sampling method were analyzed morphometrically in detail. The outcomes were statistically correlated with the student T-test and Chi-square test to determine the functionality.

Results: In this present study, the mandibular criteria like the greatest width of the Ramus, least width of the Ramus, the projective height of the condyle, and coronoid height were statistically significant when compared between males and females. The gonial angle was higher in females than males but not statistically significant. In this study, the most common were the angled condyle, triangular coronoid process, and wide sigmoid notch.

Conclusion: The mandible, being the most remarkable bone, is used as the frame of reference for the placement of surgical grafts, implants, and orthognathic surgeries. Identification of sex remains an important feat in forensic odontology. This is aided by the morphometric analysis and anthropology of the mandible on OPG. This study succeeds in emphasizing the necessity of a comprehensive analysis of differing mandibular parameters.

KEY WORDS Mandible, Analysis, Radiology

Introduction

Growth, development, and remodeling are integral parts of the lives of all human beings. These are specific and identical sex at different ages. These changes are well appreciated clinically by external features of an individual. However, the internal architecture often requires insights into the body. This is generally achieved by radiography in the medical field, which is of great value. One such method is dentofacial radiography which is a methodical proceeding employed in dental, medical clinics, and hospitals wherein radiographs are exposed for discrete intents at different periods of a lifetime in a broad population. Radiography is an unadorned and forthright way of revealing the diversity among males and females at different ages, which can eliminate the need for various histological and biochemical methods.

The pelvis and the mandible are the two bones that are most imperative for distinguishing age and gender. The mandible undergoes a lot of morphological transitions during aging, and its ramus and condyle are the most sexually dimorphic bones as they are associated with a lot of changes in size and growth due to remodeling progress.

The Orthopantomogram (OPG) is a single panoramic image of the maxilla, mandible, dentition, and surrounding osseous complex. It is a universally accepted mode of radiography because of its wide visualization of dental arches and because it is a convenient, inexpensive, and expeditious way of evaluating the gross anatomy of the teeth and the mandible.

The events of growth and development must be correlated with the maturational level of each individual to identify the skeletal pattern and the residual growth and to decide on a proper treatment plan. [1]

Mandibular dimorphism is affected by the size and shape of the masticatory muscles since the masticatory force varies between men and women. Traditionally, the mandible in males is larger and heavier than in females by reason of a superior skeletal framework, bulkier musculature, and augmented occlusal forces. In addition, there are numerous nonmetric dimensions that help in differentiating the male from the female mandible. The mandible undergoes constant re-modeling during the aging process. The length and breadth of the ramus increase with age, whereas the angle of the mandible decreases with age and the shifting of the mental foramen. The mandibular plane angle decreases with age, suggesting the tendency for a closing rotation of the mandible. [1] Hence, the parameters of the mandible vary with age, gender, race, and occlusal surface. Age estimation and gender of the bone are very imperative components of the study in the fields of anthro-

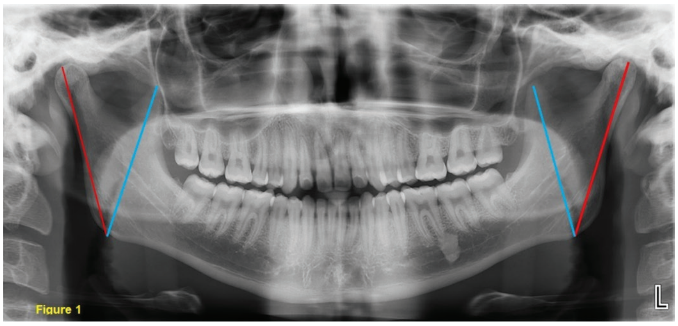

Figure 1: *Depiction of the Projective height of the condyle and the Height of the Coronoid process. (The RED LINE denotes the Height of the condyle and the BLUE LINE denotes the Height of the Coronoid process)*

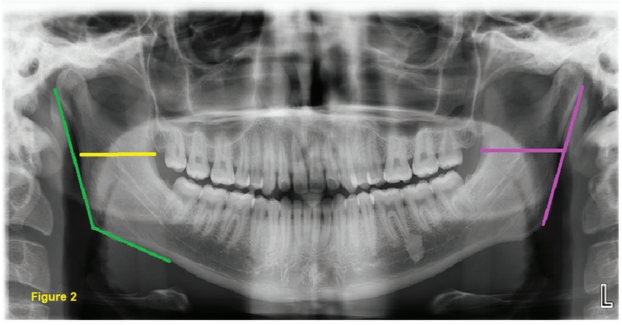

Figure 2: *Depiction of the Maximum Ramus width, Minimum Ramus width, and the Gonial angle. (PINK LINE denotes the Maximum Ramus width, the YELLOW LINE denotes the Minimum Ramus width and the GREEN LINE denotes the Gonial angle.)*

pology and forensic sciences, as further interpretations and analyses are based on them. Normally, morphological and metric analyses are used to determine the age and gender of the bone. [2,3] The age and gender of an unknown individual can be determined based on the morphology and metric features of the skull and mandible, soft tissues, dental records, as well as DNA analysis of teeth. [4] The maximum growth of the mandible occurs in adolescents, and the masticatory muscles play a significant role in the dimensions. With increasing age, there is an increase in the contractile activity of the masticators, and after the 3rd to 4th decade of life, there is reshaping of the muscle density, causing reshaping of mandibular bone joint components and drastically influencing the morphological characteristics. [4].

The mandible may play a vital role in age estimation and gender determination as it is the most dimorphic, largest, and strongest bone of the skull. The presence of a dense layer of compact bone makes it very durable, and hence, it remains better preserved than many other bones. The mandible is the toughest face bone and, according to researchers in forensic and physical anthropology, it preserves its morphology better than other bones.

So, in order to effectively place surgical grafts and implants, perform orthognathic procedures, and perform replacement surgeries, anthropological studies, and forensics, etc, it is vital to understand the morphometric characteristics of the mandible such as the greatest width of the ramus, the least width of the ramus, the projective height of the condyle, and coronoid height, in both males and females.

Design Of The Study

The present study was an invitro study, planned and conducted at the Department of Oral Medicine and Radiology, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India. The study was envisaged to measure the various mandibular parameters, namely maximum ramus breadth, minimum ramus breadth, coronoid height, projective and actual condylar height, the shape of the coronoid, condyle, sigmoid notch, and the gonial angle on the OPG, and correlate or compare these parameters between male and female groups in the study population, as well as evaluate the reliable predictive values of these mandibular parameters in gender determination and sex identification using mandible bone, so that it will aid in formulating the guidelines for planning various surgical methods, in anthropological studies and in forensic studies.

Purposive sampling was used to collect the sample, and the study sample size was computed using the formulary.

N = (Z2) P(1-P)/d2, where n = study sample size, z = level of confidence, P = Prevalence, and d = allowable error. This formula assumes that P and d are decimal values, but it would also be correct if they were percentages, with the exception that the term (1 – P) in the numerator would become (100 – P).

TABULATION

Table 1: Age wise distribution of the study sample

Age	Male	Female	Total
11 – 20 years	4	4	8
21 – 30 years	14	13	27
31 – 40 years	8	8	16
41 – 50 years	16	15	31
51 – 60 years	12	12	24
61 – 70 years	52	52	104
Total	106	104	210

Table 2: Mean values of the parameters of the Mandible on Right side.

PARAMETERS OF MANDIBLE RIGHT SIDE	MALE	FEMALE
Ramus Maximum Width	33.48+/-2.74mm	32.44+/-2.94mm
Ramus Minimum Width	28.96+/-2.62mm	26.70+/-2.34mm
Condylar Height	63.56+/-4.14mm	54.22+/-4.45mm
Projective Condyle Height	62.75+/-4.45mm	53.21+/-4.68mm
Coronoid Height	58.21+/-4.02mm	49.92+/-4.27mm
Gonial angle	134.09+/-5.74deg	133.09+/-5.92deg

Exceptional diagnostic quality OPGs with a full complement of permanent teeth aged between 18 and 70 years without more than one missing tooth in each quadrant, particularly in the mandibular arch, were considered for analysis.

OPGs of the patients with bony lesions and/or fractures, a history of trauma and/or previous surgeries involving either of the jaws, temporomandibular joint disorders, endocrinal and metabolic disorders, or malocclusions except for Angle's class I, weren't considered for the study. OPGs with positioning errors, magnification errors, and superimposition in the area of interest were barred from the study.

Materials and methods

- The present study examined the following mandibular parameters:
- **A:** Maximum ramus breadth, the distance between the most anterior and the line connecting the most posterior part of the condyle, and the angle of the mandible
- **B:** Minimum ramus breadth, the distance between the deepest anterior border and posterior borders of the ramus
- **C:** Projective Condylar height; the height of the ramus from the most superior part of the condyle to the tubercle of the most protruding portion of the inferior border of the mandible
- **D:** Maximum coronoid height: projective distance between the coronoid and the most inferior point of the lower border of the mandible
- **E:** Gonial angle: A line traced tangential to the most inferior points at the gonial angle and the lower border of the mandibular body and another line tangential to the posterior borders of the ramus and the condyle. The intersection of these lines forms the gonial angle [6].

Table 3: Mean values of the parameters of the Mandible on Left side.

PARAMETERS OF MANDIBLE LEFT SIDE	MALE	FEMALE
Ramus Maximum Width	34.11+/-2.69mm	31.98+/-2.94mm
Ramus Minimum Width	29.05+/-2.76mm	26.32+/-2.30mm
Condylar Height	63.35+/-4.29mm	53.89+/-4.45mm
Projective condyle Height	62.58+/-4.28mm	53.08+/-4.65mm
Coronoid Height	58.71+/-4.06mm	49.65+/-4.23mm
Gonial angle	133.95+/-5.93deg	134.02+/-6.29deg

Table 4: Tabulation depicting the Shape of the Condyle on Right and Left side in Males and Females

Shape of the Condyle	Male (R)	Female (R)	Male (L)	Female (L)	Total
Angled	80	52	80	58	270
Bifid	0	2	0	1	3
Flat	0	3	0	2	5
Round	26	47	26	43	142

(R= Right, L= Left)

Observation & Results

The participants in the present study ranged in age from 18 to 70 years, with 106 males and 104 females. The study sample was classified according to their age into different strata (Table 1). The mean values of the morphological parameters of the mandible, like maximum ramus breadth, minimum ramus width, projective condylar height, maximum coronoid height, and gonial angle, on the right side (Table 2) and on the left side (Table 3), were measured and tabulated.

The presenting morphologies of the condyle of the study sample were classified into Angled, Bifid, Flat, and Round types (Table 4), whereas the shape of the coronoid was classified into Beak, Round, and Triangular types (Table 5), and the shape of the sigmoid notch was classified as Round, Sloping, and Wide (Table 6).

On applying an independent T-test and comparing various parameters between males and females, there was a statistically significant difference in the maximum and minimum length of the ramus of the mandible condyle on both sides, projective height, and coronoid height on both sides, with males showing a higher mean than females, but there was no statistically significant difference in gonial angles on both sides between males and females.

On applying the Chi-square test, there was a statistically significant difference between male and female shapes on both the right and left sides. On applying the Chi-square test, there was statistically no significant difference in coronoid shape between males and females. Similarly, on the Chi-square test, there was no statistically significant difference between male and female sigmoid notch shapes on the right side, but there was a statistically significant difference on the left side.

Discussion

The mandible is the most sexually dimorphic bone in the body, with the male mandible being larger due to musculature and skeletal structure. The pull of the various muscles and ligaments determines the shape of the mandible.

Table 5: Tabulation depicting the Shape of the Coronoid process on Right and Left side in Males and Females

Shape	Male (R)	Female (R)	Male (L)	Female (L)	Total
Beak	11	8	17	18	54
Round	0	0	0	2	2
Triangular	95	96	89	84	364

(R= Right, L= Left)

Table 6: Tabulation depicting the Shape of the Sigmoid notch on Right and Left side in Males and Females

Shape	Male (R)	Female (L)	Male (L)	Female (L)	Total
Round	26	15	20	19	80
Sloping	28	20	30	22	100
Wide	52	69	56	63	240

(R=Right, L= Left)

Therefore, it is a requisite to appreciate the gender-specific constructural facets of the mandible in males and females at different junctures as a frame of reference for placing surgical grafts and implants, planning orthognathic surgeries and replacement surgeries, and in anthropological studies and forensics. Therefore, the mandible is extensively employed for analysis, as there is a dearth of standards utilizing this element and it is frequently recovered in largely intact condition. [2,7].

OPG is the most ubiquitous form of radiography accessible for the study of the mandible. It is advantageous due to the low radiation dose and short span of time required for procuring the images. It is of utmost advantage in that interference from superimposed images is not encountered, whereas the contrast, brightness enhancement, and enlargement of images provide an accurate and reproducible method of measuring the chosen points [8].

Maximum Ramus Width

In the present study, the maximum ramus width on the right side in males was 33.48 +/- 2.74 mm and 33.41 +/- 2.64 mm on the left side. The maximum ramus width in females on the right side was 32.44 +/-2.94 mm and 31.98 +/-2.94 mm on the left side. It was comparable to the study done by More et al. [9], where the mean maximum ramus width of both the right and left was 33.29 +/-3.23 mm in males and 26.51 +/-3.53 mm in females.

In an independent study done by Ojha et al. [10], the maximum ramus width in males on the right side was 48.87 +/- 8.18 mm and 49.07 +/- 8.57 mm on the left side. It was 49.10+/-7.63mm on the right side and 50.06+/-7.93mm on the left side in females. Similarly, a study by Ranaweera et al. [11] revealed the mean maximum ramus width in males to be 46.68 +/- 4.46 mm and 43.17 +/- 4.63 mm in females. In this study, the mean maximum ramus width was comparable between the sides and significantly higher in males than females, as discerned in other studies.

Minimum Ramus Width

In the current study, the minimum ramus width was calculated to be 28.96 +/- 2.62 mm on the right side and 29.05 +/- 2.76 mm on the left side in males. It was found to be 26.70+/-2.34 mm on the right side and 26.32+/-2.30 mm on the left side in females. The minimum ramus width in males, according to Shahabi et al. [8], was 29.42 +/-3.14 mm in males and 29.55 +/-2.83 mm in females. According to More et al. [9], it was 28.35 +/-3.01 mm in males and 28.35 +/-3.01 mm in females. In a study done by Ojha et al. [10], the minimum width in males on the right side was 42.68 +/- 7.19 mm and 42.59

+/- 7.48 mm on the left side. In females, the minimum width was revealed to be 42.67+/-6.46mm on the right side and 43.23+/-9.47mm on the left side. In comparison to a study done by Ranaweera et al. [11], the minimum ramus width was 31.09 +/-3.46 mm in males and 30.24 +/-3.57 mm in females. The Minimum Ramus Width was significantly higher in males than females akin to the other studies.

The statistically significant results of this study, regarding the maximum and minimum ramus width, are similar to those of the various authors, but the subservient acreage can be attributed to racial, genetic, ethnic, and socio-economic variabilities.

Projective height of the Condyle

In this study, the projective height was calculated to be 62.75 +/- 4.45 mm on the right side and 62.58 +/- 4.28 mm on the left side in males. It was measured to be 53.21+/-4.68mm on the right side and 53.08+/-4.65mm on the left side in females. The projective height according to Shahabi et al. [6] was 66.19 +/-4.75 mm in males and 60.08 +/-4.30 mm in females. The projective ramus height as measured by More et al. [9] was 68.14 +/- 5.65 mm in males and 63.09 +/-5.67 mm in females. It was depicted in the study done by Ojha et al. [10] that the projective ramus width was 101.01 +/-15.87 mm on the right side and 104.05 +/-16.06 mm on the left side in males. It was 99.66+/-15.40mm on the right side and 102.80+/-15.60mm on the left side in females. In an independent study by Ranaweera et al. [11], the projective height in males was 82.10 +/-6.75 mm and 72.89 +/-6.40 mm in females. Analogous to other studies, our analysis led to statistically significant values in males as opposed to females.

Coronoid height

In this study, the coronoid height was 58.21 +/- 4.02 mm on the right side and 58.71 +/- 4.06 mm on the left side in males. The coronoid height was 49.92 +/- 4.27 mm on the right side and 49.65 +/- 4.23 mm on the left side in females. Accordingly, in an analysis done by Shahabi et al. [8], the coronoid height was 55.98 +/-6.54 mm in males and 51.32 +/-4.66 mm in females. The coronoid height according to More et al. [9] was 61.38 +/- 5.71 mm in males and 57.08 +/- 5.68 mm in females. It was concluded in the study done by Ojha et al. [10] that the coronoid height was 92.20 +/-13.34 mm on the right side and 92.90 +/-13.15 mm on the left side in males. The coronoid height was found to be 92.20 +/-13.35 mm on the right side and 90.44 +/-12.46 mm on the left side in females. It was measured to be 73.73 +/- 5.64mm in males and 66.60 +/- 6.09mm in females in a study by Ranaweera et al. [11]. The coronoid height was much related to the analyses of More, Shahabi et al. [9,8] and statistically significant in males than females.

Gonial angle

The gonial angle as measured in this study was 134.09+/-5.74 deg on the right side and 133.95+/-5.93 deg on the left side in males and 133.09+/-5.92 deg on the right side and 134.02+/-6.29 deg on the left side in females. In a study done by Shahabi et al. [8], the gonial angle in males is 172.94 +/- 31.89 degrees and 152.71 +/- 14.69 degrees in females. The gonial angle was measured to be 122.16 +/- 7.51 degrees on the right side and 122.08 +/-10.02 degrees on the left side in males in a study done by Ojha et al. [10]. Furthermore, it was measured to be 132.26 +/- 98.05 degrees on the right side and 124.92 +/- 10.97 degrees on the left side in females. The gonial angle was higher in females than males, but in the present study, it was not statistically significant.

In accordance with this study, the characteristics like maximum ramus breadth, minimum ramus breadth, coronoid height, and projectile height on both sides showed statistically significant higher values in males compared to females.

In the study done by Ranaweera et al. [11], the maximum ramus width, minimum ramus width, condylar height, gonial angle, and projectile height were statistically significantly higher in males than females ($p<0.05$). The condylar height showed the highest sexual dimorphism. According to the study done by Ojha et al. [10], parameters like the maximum ramus breadth, minimum ramus breadth, coronoid height, and gonial angle were found to be higher in males than females, though statistically insignificant. The coronoid height showed the highest sexual dimorphism.

By comparing and contrasting the results of this study with various other studies, it can be inferred that the males showed superior predominant mensuration, but the discrepancies in the overall measurements can be attributed to the fact that these studies were carried out on different pockets of population with varying ethnic, racial, genetic, and prevailing socio-economic circumstances. Although most of the studies revealed conventionally prodigious measurements in males when compared to females, studies with antithetical parameters call for the formulation of a standardized protocol for detailed morphometric analysis of the mandible.

Coronoid process- Shape

In this study, the triangular shape of the coronoid is most common, with 191 (95 males and 96 females) on the right side and 173 (89 males and 84 females) on the left, followed by beak shapes of 19 (11 males and 8 females) on the right side and 35 (17 males and 18 females) on the left side. The round type of coronoid was the least common; 2 seen on the left side in females. It is similar to the observation done by Nagaraj et al. [14] in 300 subjects, where the triangular shape was the most commonly observed in 187 (98 males and 89 females) on the right and 150 (86 males and 64 females) on the left, followed by a round in 43 (28 males and 15 females) on the right side and 78 (48 males and 30 females) on the left, and beak-shaped in 56 (38 males and 18 females) on the right side and 54 (29 males and 25) on the left side. The least common was flat-shaped in 14 (9 males and 5 females) on the right side and 18 (10 males and 8 females) on the left side. In an analysis of the South Indian population by Shakya et al. [12], similar results were obtained, with the triangular type of coronoid process being the most common, with 127 (68 males and 59 females) on the right side and 121 (62 males and 59 females) on the left side, followed by rounded 66 (33 males and 33 females) on the right side and 43 (7 males and 36 females) on the left side, followed by beak-shaped 7 (1 male and 6 females) on the right side and 5 (2 males and 3 females) on the left side, The least common type was flattened type seen only 1 on the left side in a male.

Condyle process - Shape

In a detailed analysis by this study, it was found that the angled type of condyle was most common: 132 (80 males and 52 females) on the right side and 138 (80 males and 58 females) on the left side, followed by the round variety: 73 (26 males and 47 females) on the right side and 69 (26 males and 43 females) on the left side. It was followed by flat condyles: 3 (three females) on the right side and 2 (two females) on the left side. The bifid type of condyle was least common, seen in 2 females on the right side and 1 female on the left side.

Accordingly, a study by Nagaraj et al. [14] depicted that the most common type of condyle was round: 122 (68 males and 54 females) on the right side and 135 (69 males and 66 females) on the left side, followed by angled condyles: 91 (46 males and 45 females) on the right side and 81 (49 males and 32 females) on the left side. This was succeeded by a convex condyle in 75 (41 males and 34 females) on the right side and 66 (38 males and 28 females) on the left side. The flat condyle was the least common type seen in 12 (7 males and 5 females) on the right side and 18 (10 males and 8 females) on the left side. Similarly, a study done by Rani et al. [13] revealed the round type of condylar process was most common: 138 (68 males and 70 females) on the right side and 151 (78 males and 73 females) on the left side, followed by the angled type: 134 (79 males and 55 females) on the right side and 147 (89 males and 58 females) on the left side. It was succeeded by convex condyles 88 (53 males and 35 females) on the right side and 64 (37 males and 27 females) on the left side. The least common type was flat, seen in 8 (5 males and 3 females) and 6 (1 male and 5 females) on the left side.

Sigmoid notch - Shape

In the present study, the wide type of sigmoid notch was seen more commonly in 121 (52 males and 69 females) on the right side and 119 (56 males and 63 females) on the left side, followed by sloping 48 (28 males and 20 females) on the right side and 52 (30 males and 22 females) on the left side, and round 41 (26 males and 15 females) on the right side and 39 (20 males and 19 females) on the left side. This is very similar to a study done by Rani et al. [13], where wide is the commonest 162 (86 males and 76 females) on the right side and 146 (77 males and 69 females) on the left side. Sloping type is common: 115 (65 males and 50 females) on the right side and 134 (73 males and 61 females) on the left side. The least common type was a round-shaped sigmoid notch seen in 91 (54 males and 37 females) on the right side and 88 (55 males and 33 females) on the left side. In a study done by Shakya et al. [12], the sloping type of sigmoid notch was more common. Out of 200 OPG, sloping was seen in 93 on the right (50 males and 43 females) and 89 (40 males and 49 females) on the left. It was followed by a round shape of 67 (31 males and 36 females) on the right side and 56 (33 males and 23 females) on the left side. The wide type of sigmoid notch was the least common, with 40 on the right side (21 males and 19 females) and 55 (29 males and 26 females) on the left side.

The increased prevalence of triangle shaped coronoid in this study was equivalent to the outcome of Nagaraj et al[14] and Shakya et al[12] studies but the angled condyle which was prevalent in this study was the second most common with the studies done by Nagaraj et al[14] and Rani et al[13]., Nevertheless, the ubiquitous Wide sigmoid notch of the present study complemented with the study by Rani et al [13]and showed disparity with Shakya et a [12]., where it was second most common presentation. This varied morphological presentation in the shape of the mandibular features in different studies correlates with the racial or ethnic genetic background of the study population.

Conclusion

Gender estimation is the most climacteric in the placement of surgical grafts and implants, planning orthognathic surgeries and replacement surgeries, and in the fields of anthropology and forensic sciences. This can be effectively carried out by morphometric analysis of the mandible, presumably under standardized protocol criterion formulated in consideration of varying morpho proportions liable to racial, ethnic, and genetic repercussions. This study renders an explicit detailing about most of the parameters involved in the study of the mandible on an orthopantomogram, which are not provided in other studies. These parameters have been commodiously studied and this helps in the detailed perusal of the mandible. Since OPG is despicable and accessible to the population, this paves the way for future research in morphometric analysis of the mandible. **R**

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Declaration

Ethical Approval: Ethics are upheld in conformity with the 1964 Helsinki Declaration and its following revisions Prior to the investigation, an ethical clearance was obtained by the university's IEC (IEC No 28/2021). (JSS DENTAL COLLEGE AND HOSPITAL INSTITUTIONAL ETHICAL COMMITTEE) dated 13/12/2021. Informed consent was taken from all the participants involved in the study.

Conflict of interest: No competing interests of a financial or personal nature

Availability of Data and Materials: The complete database pertaining to the study is preserved as an electronic database with the corresponding author and can be retrieved at any point in time.

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