Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2024;41:65-70

A Radiomorphometric Analysis of Mandibular Morphological Variations Linked to Sexual Dimorphism

Karthikeya Patil[1], Sanjay C J[2], Mahima V Guledgud[3], Viveka S[4], Vidya G Doddawad[5], Sowmya S[6]

[1]Department of Oral Medicine and Radiology, Head and Professor, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India
[2]Department of Oral Medicine and Radiology, Reader, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India
[3]Department of Oral Medicine and Radiology, Reader, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru India
[4]Department of Oral Medicine and Radiology, Postgraduate Student, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India
[5]Department of Oral Medicine and Radiology, Associate Professor, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India
[6]Department of Prosthodontics and Crown and Bridge, Associate Professor, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India

Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: sex determination from unknown skeletal remains play an essential role in the fields of forensics and anthropology. Since the mandible is the largest and sturdiest facial bone and is frequently injury-resistant, it is a crucial resource for knowledge regarding sexual dimorphism. The present study was aimed to measure and differentiate sex-related mandible changes in the South Indian population on digital panoramic radiographic images and to evaluate their reliability in sex determination that might serve as evidence in forensics.

Methods: this was a cross-sectional study performed on digital panoramic images of 620 patients. One angular measurement (gonial angle) and four linear measurements (condylar length, ramus length, cortical bone thickness, and ramal notch width) were assessed. The data obtained was subjected to statistical analysis.

Results: the males have higher values than females across all metrics considered in our study. A significant difference of $p<0.05$ was noted among males and females when gonial angle, condylar length and ramus length was considered. There was no statistical significance when comparing cortical bone thickness and ramal notch width between males and females.

Conclusion: males have higher values than females on comparing the gonial angle, condylar length, ramus length, cortical bone thickness and ramal notch width. This study recommends the use of the mandibular parameters in Orthopantomogram reliable for the purpose of sex determination.

Keywords: Forensic science; Forensic anthropology; Gender determination; Orthopantomography; Mandible.

Introduction

Establishing one's identity is critical for the unknown deceased person in homicide, accidents, suicide, and catastrophic disasters such as terrorist attacks, explosions, earthquakes, and plane accidents, as well as for criminals who are concealing their identities[1]. Identification of the sex of the human skeleton remains of an unknown deceased person is regarded as the first difficult step in forensics[2]. Few studies have focused on using several skeleton traits to determine disparity related to sex and ethnicity to improve forensic identification[2,3]. Many studies have proven that the pelvis and skull bones demonstrate the highest sexual dimorphism of around 98% and could be used for this purpose[4,5,6]. Bone morphology change at a constant rate throughout a person's life, and those changes in the skeleton follow a chronological pattern[3]. Knowing what changes take place in the bones can help determine sex from the skeleton. The mandible is the largest, strongest, and most mobile component of skull, and its identification is the most crucial aspect in anthropological research and medico-legal matters[6].

Radiology plays a vital role in determining an individual's age and sex[3]. No two radiographs are alike, and this ideology is implicated in determining an individual's sex. Panoramic radiography is a common modality in routine dental check-ups and an employed method in scientific research and criminal investigations[7,8]. Even though there are a variety of ways of determining sex, Orthopantomography (OPG) can provide anatomical measurements with accuracy when the exterior features are damaged[9].

DOI: 10.51929/jms.41.65.2024
ISSN 2177-0298

In this study, the different dimensions of the mandible as seen on OPG were measured, evaluated, and compared between the sexes, thereby recommending OPG as an accurate tool in gender determination.

Materials and Methods

The present study was a cross sectional study conducted on patients who reported to the outpatient department and were advised OPG [Planmeca Promax- SCARA 3, Planmeca, Finland] for diagnostic purposes. The study was conducted from June 2021 to May 2022. The institutional ethics committee was acquired [JSSDCH IEC Protocol No: 63/2019 dated on 25/10/2019] prior to commencement of the study.

Inclusion criteria - Subjects ranging from 12 to 70 years, ideal digital panoramic radiographic images with optimum diagnostic quality, (no artifacts, no magnification errors and clearly showing reference landmarks like condyle, ramus, gonial angle) were included.

Exclusion criteria - Patients with systemic disorders affecting the jawbone (rheumatoid arthritis, osteoarthritis etc), patients who had temporomandibular joint disorders, maxillofacial trauma/surgery, or orthognathic treatment in the past, Patients who suffer from congenital maxillofacial malformations or syndrome, completely edentulous mandibular arch were excluded.

The sample size estimated was 620. All participants were separated into 4 different groups based on their age range. Four different age groups used were: 12–18 years [group 1]; 19–40 years [group 2]; 41–60 years [group 3] and 61–70 years [group 4][7]. Out of 620 subjects, 310 (50%) were males and 310 (50%) were females. All Linear and angular measurements were made on digital panoramic images for all parameters on both sides using Planmeca Romexis software version 3.2.0.R. The parameters that were measured in present study were as follows[7]:

1. Gonial angle (GA): It is formed by drawing a line between two imaginary lines that extend from lower border of mandible to ramus of mandible.
2. Condylar length (CL): It is the distance measured between two tangential lines that are drawn at the superior most point of condylar head and another at the base of curvature of sigmoid notch.
3. Ramus length (RL): It is calculated by drawing two lines, both perpendicular to ramus tangent line, one at the level of the most lateral image of the condyle and the other at the level of most lateral image of ramus. The distance between these two lines is RL.
4. Cortical bone thickness: The thickness of the radiopaque band is measured at lower border of mandible's body, where antegonial notch begins mesially.
5. Ramal notch depth (RND): It is calculated by drawing a line from the ramus tangent line to the ramus notch concavity's deepest point. [Figure 1]

Statistical analysis

All collected data were tabulated and statistically analysed using SPSS software version 22.0. Independent sample t-test was used to compare the mean values of gonial angles, condylar length, ramus length, ramal notch width and cortical bone thickness between males and females in four different age groups was assessed. P-value less than 0.05 was considered to be statistically significant.

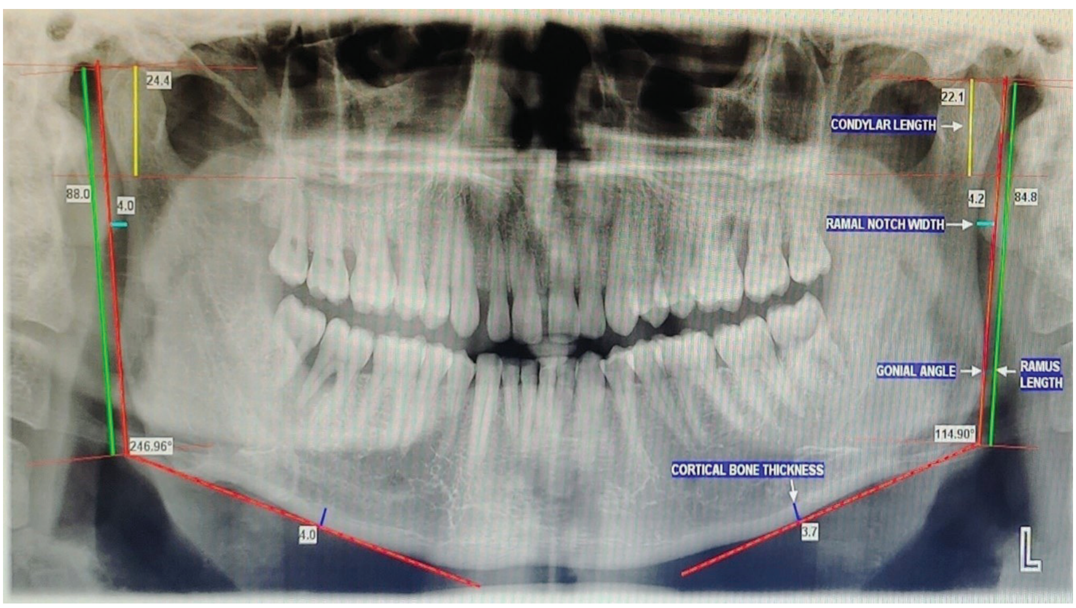

Figure 1. is a panoramic image showing gonial angle (red line), condylar length (yellow line), ramus length (green line), ramal notch width (light blue line) and cortical bone thickness (dark blue line) that are measured with Planmeca Romexis Software.

Results

Table 1 indicates the age and sex distribution of the study group. All subjects were divided into 4 categories i.e., 12-18 years of age [group 1], 19–40 years of age [group 2], 41–60 years of age [group 3], and 60-70 years of age [group 4]. The mean age of the participants in group 1 was 15.0±1.2 years, in group 2 was 27.0 ±2.5, in group 3 was 48.0± 0.84 and in group 4 was 66.0 ±3.04. All the parameters had higher male measurements than females and hence each variable was a significant predictor in classifying the gender.

The mean value of gonial angle among 310 males was 181.09°, and among 310 females it was 179.89° which was statistically significant with the p-value of 0.002. Males had higher values than females in all age groups. Comparing the values between the sides, right side depicts comparatively higher values than the left in both males and females in all age groups. [Table 2,3,4 shows the parameters and values compared between males and females]

The mean value of the condylar length among 310 males was 22.39 mm and among 310 females was 21.28 mm. This was statistically significant with the males depicting comparatively higher values than females. (p = 0.001). Right side shows higher values than the left side across all age groups on comparing the sides except in group 4 where condylar length was higher on left side in females as shown in tables 2,3,4.

The mean value of the ramus length among 310 males was 71.57 mm and among 310 females was 66.67 mm. A statistically significant difference was noted between the genders and males had higher values than

Table 1. Frequency distribution of study participants by age and sex along with mean values (n=620).

Age in Years	Sex		Total n (%)
	Male n (%)	Female n (%)	
12-18	90 (14.51%)	90 (14.51%)	180 (29.03%)
19-40	90 (14.51%)	90 (14.51%)	180 (29.03%)
41-60	90 (14.51%)	90 (14.51%)	180 (29.03%)
61-70	40 (6.45%)	40 (6.45%)	80 (12.90%)
Total	310 (49.98%)	310 (49.98%)	620 (100.0%)

Table 2. Comparison of each parameter's mean value in males.

Parameters	Side	12-18 Years Mean±SD	19-40 Years Mean±SD	41-60 years Mean±SD	61-70 years Mean±SD
Gonial Angle (°)	Right	233.35±5.70	237.82±6.22	239.75±5.98	239.69±7.51
	Left	129.70±18.26	123.69±6.52	122.26±6.42	121.92±7.34
Condylar Length (mm)	Right	20.48±3.52	23.44±4.07	22.86±4.61	24.89±4.23
	Left	20.34±4.47	23.28±5.39	22.44±3.57	23.13±5.68
Ramus Length (mm)	Right	66.51±11.99	73.65±8.63	73.29±9.25	76.51±4.23
	Left	65.99±12.44	72.93±8.57	72.76±8.76	76.31±3.64
Cortical Bone Thickness (mm)	Right	3.09±0.73	3.62±0.68	4.04±0.72	4.05±0.81
	Left	3.23±0.78	3.70±0.76	4.05±0.74	4.02±0.71
Ramal Notch Width (mm)	Right	2.24±1.01	2.93±1.16	3.04±0.81	3.55±1.07
	Left	2.25±0.90	3.33±1.28	3.07±0.97	3.80±1.19

Table 3. Comparison of each parameter's mean value in females.

Parameters	Side	12-18 Years Mean±SD	19-40 Years Mean±SD	41-60 years Mean±SD	61-70 years Mean±SD
Gonial Angle (°)	Right	233.22±6.59	233.67±14.97	237.27±7.51	235.36±4.03
	Left	127.00±6.71	124.55±7.77	123.36±7.56	125.10±4.49
Condylar Length (mm)	Right	21.81±4.02	21.18± 4.08	21.97±3.74	19.95±2.69
	Left	21.57±4.27	21.07 ±4.05	21.54±3.94	20.81±3.19
Ramus Length (mm)	Right	65.95±6.64	67.89±5.97	67.21±6.81	65.97±5.81
	Left	65.40±6.56	67.81±5.78	66.81±6.69	64.94±5.98
Cortical Bone Thickness (mm)	Right	3.44±0.55	3.63±0.57	3.65±0.76	3.97±1.05
	Left	3.61±0.45	3.72±0.51	3.68±0.79	3.43±1.04
Ramal Notch Width (mm)	Right	2.81±0.98	2.61±0.88	2.75±1.02	2.99±1.04
	Left	2.95±0.88	2.84±0.97	2.87±0.86	3.18±1.07

Table 4. Comparison of each parameter's mean value between males and females.

Parameters	Gender	12-18 years	19-40 years	41-60 years	61-70 years	Mean±SD	dF	p-value
Gonial Angle (°)	Male	181.64± 8.83	180.76±1.87	180.99± 2.21	180.79± 1.99	181.09±3.057	618	.002*
	Female	180.11± 1.89	178.89± 8.04	180.27± 2.35	180.25± 1.74	179.89±3.05	614.47	
Condylar Length (mm)	Male	20.42± 3.75	23.36± 4.48	22.65± 3.97	24.01± 4.21	22.39±3.41	618	.001*
	Female	21.00± 4.00	20.77± 3.84	21.44± 3.74	20.18± 2.80	21.28±3.41	607.47	
Ramus Length (mm)	Male	66.25± 12.17	73.29± 8.44	73.02± 8.82	76.41± 3.54	71.57±7.32	618	.000*
	Female	65.36± 6.47	67.60± 5.65	66.67± 6.64	65.20± 5.66	66.67±7.32	518.11	
Cortical Bone Thickness (mm)	Male	3.16± .072	3.65± 0.66	4.04± 0.70	4.04± 0.72	3.60±1.37	618	.170
	Female	3.50± 0.46	3.66± 5.65	3.59± 0.75	3.28± 1.02	3.68±1.37	599.08	
Ramal Notch Width (mm)	Male	2.25± 0.90	3.14± 1.16	3.04± 0.85	3.67± 1.08	2.92±0.97	618	.330
	Female	2.75± 0.87	2.59 ±0.84	2.62± 0.89	2.91± 1.02	2.84±0.97	593.04	

*: p-value <0.05 was considered as statistically significant.

females (p=0.000). While considering the sides, right side shows comparatively higher values than the left in both males and females in all age groups.

The mean value of the cortical bone thickness among 310 males was 3.681 mm and among 310 females it was 3.60 mm. No statistically significant difference was noted between males and females (p = 0.170). While comparing the sides, the left side showed higher values than the right side in age groups 1,2,3 in both males and females.

The mean value of ramal notch among males was 2.92 mm and among females it was 2.84 mm. There was no statistical significance between the males and females (p=0.330). While comparing the sides, left side showed higher values than the right side across all age groups in both the genders.

Discussion

In forensic anthropology, the estimation of distinct attributes of each individual to help in identification or to serve as proof of a suspected identification is usually done using human osteological remains[10]. Based on morphological features, a person's gender can be determined subjectively and is more likely to be correctly identified. To determine sex from the skull, methods based on measurements and morphometry are dependable and can be used.

It has been established in the past that panoramic radiography accurately provides anatomical measurements. Nowadays, panoramic radiographs are frequently utilized as a reliable screening technique for identifying oral problems. Broad coverage, minimal patient radiation exposure, and quick imaging acquisition are some of the main benefits of panoramic radiography. Magnification and geometric distortion are the limitations of panoramic radiography[11]. This constraint, however, had no impact on our findings because all images were consistently scaled.

In this study, there was no difference between males and females gonial angles. The males had higher values than the females. This above statement is in contrast with the results of Chole *et al.*,[7] Joo *et al.*,[12] and V. Sairam *et al.*, who observed a wider gonial angle among female subjects than that of males[7,12,13]. Larheim *et al.*, in his study found no noticeable difference between the genders[14]. This variation might be explained by the different sample sizes and the research population's age range (14–28 years) conducted by Larheim *et al.* Overall, this parameter (gonial angle) is found to be a promising parameter in sexual dimorphism.

According to Humphrey *et al.*'s study from 1999, there is a considerable variation among males and females in condylar length. On the other hand, Jeong-Ki Joo *et al* study's identified no significant differences in condyle length between male and female groups using digital panoramic radiography to detect gender[13,15]. Among both males and females, this study found significant difference in condylar length between both sides of the jaw. A study conducted by Krisjane *et al.* also concluded a significant difference between right and left condylar lengths[16]. Overall, this parameter (condylar length) was found to be a promising parameter for sex determination.

Ramus length variations between males and females were also discovered in this study. This claim is supported by a number of additional research, including those by Morant *et al.* (1936)[15], Humphrey *et al.* (1999)[17], Hrdlicka (1940)[18], and Mangla *et al* (2011)[19]. In this study, it was discovered that males had longer rami than females. This assertion is also consistent with the research conducted by Mangla *et al.* (2011), who observed that males have longer rami than females[19]. Among both sex groups, we noticed a significant difference in ramus length between both sides of the jaw, which was found to be statistically significant with the males showing a higher value. (p = <0.05). Overall, this parameter (ramus length) was a promising parameter for sex determination.

The cortical bone thickness was significantly higher in males compared to females which was not statistically significant (p=0.170). The above statement was shown to be in complete accordance with the study presented by Jeong-ki Joo (2012)[13]. We also found that when comparing right and left sides, the left side had slightly higher values in certain age groups.

In our study, ramal notch width was higher in males than females. The values were greater in left side compared to right side across all age groups. Overall, the ramal notch width was observed to be significant in determination of sex.

Numerous studies[5,6,7] have shown that each group has unique bone traits and have stressed about necessity for population-specific osteometric criteria for determining sex. Table 5 depicts the various mandibular parameters assessed in other populations. Not one skeletal indication should be relied upon primarily if additional verified dimorphic regions are available; the maximum chance of a gender determination comes from a thorough study of all known bones belonging to a specific individual.

Table 5. Mandibular parameters analysed in previous studies in different populations.

Sl nº	Author's name and year	Place of study	Sample size	Parameters compared	Conclusion
1	Poongodi, *et al*[20] 2015	India	Males-113 Females- 87	gonial angle, width of the ramus, height of condyle and coronoid	Males have higher values of the gonial angle, ramus height than females
2	Taleb NSA *et al*[21] 2015	Egypt	Males-105 Females-86	Upper ramus breadth, lower ramus breadth, projective height, condylar ramus height and coronoid ramus height and gonial angle	The accuracy of prediction was 81% in males and 77.9% in females and an overall accuracy of 79.6%.
3	Pangotra, *et al.*[22] 2018	India	Males-50 Females-50	maximum ramus breadth, minimum ramus breadth, condylar ramus height, projective ramus height, and coronoid ramus height.	Sex was accurately determined in 44 cases of 50 male mandibular measurements with prediction accuracy rate of 88% and sex was accurately determined in 46 cases of 50 female mandibular measurements with an accuracy rate of 92%.
4	Aruleena Shaminey *et al*[23] 2019	India	Males-100 Females-100	maximum ramus breadth, minimum ramus breadth, condylar height, projective height of ramus, coronoid height, height of mandible, superior margin of mental foramen to inferior border, inferior margin of mental foramen to inferior border, superior margin of mental foramen to alveolar crest, gonial angle, antegonial angle and antegonial depth	The projective height of the ramus is the most significant of all the parameters, which may be used for gender determination using the mandible
5	Ostovar Rad *et al.*[24] 2020	Iran	Males- 217 Females- 315	Ramus height, Coronoid height, mental height, mandible body height, minimum width of the ramus, the distance between the right and left gonial angle, intercondylar distance, intercoronoid distance	All parameters of mandible had sexual dimorphism and showed that they are reliable parameters with a total accuracy of 82.5% in the sexual dimorphism.
6	Saloni, *et al.*[25] 2020	India	Males-74 Females-126	maximum ramus breadth, minimum ramus breadth, condylar height, projective height of ramus, and coronoid height	The overall accuracy for determining sex from mandibular ramus was found to be 77.6%, whereas for determining male and female, the accuracy was 78.4% and 76.8%, respectively.
7	Mehta, *et al.*[26] 2020	India	900 males and 900 females	maximum ramus breadth, Minimum ramus breadth, Condylar height, Projective height, Coronoid height, Mandibular Angle	The overall accuracy rate was around 75%. However, the accuracy increases to more than 85% when two or more predictors were cumulatively calculated for gender determination of the mandible.
8	Ranaweera *et al*27 2020	Srilanka	175 males and 175 females	maximum ramus breadth, minimum ramus breadth, condylar height, projective height, coronoid height	condylar height was found to be more reliable to determine sex. The study revealed higher identification rates for males (77.1%) and females (73.7%) with a total accuracy rate of 75.4%
9	Present study 2022	India	Males-310 Females-310	gonial angle, condylar length, ramus length, cortical bone thickness, and ramal notch width	Gonial angle, condylar length and ramus length can be considered as predictors for gender determination.

Limitations of the Study

Our study cannot predict the exact gender, it can only be used to identify information regarding the gender by the value estimated. This is a population specific study so care should be taken when extending the findings to individuals of other races. Further studies are recommended to validate our hypothesis with larger sample size, including various ethnicity and socioeconomic groups for age determination.

Conclusion

Gonial angle, condyle length, ramus length, indicate anatomic differences between men and females and are statistically significant. These may be used in forensic anthropology to determine sex. These measures are encouraged for forensics when additional bones are unavailable. This study has overcome certain drawbacks of previous studies as it includes large sample size and assessment of mandibular parameters in various growth spurts from young adults to old age.

References

1. Weisberg YJ, Deyoung CG, Hirsh JB. Gender Differences in Personality across the Ten Aspects of the Big Five. Front Psychol 2011; 2:178.
2. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. J Forensic Sci 2011;56: S13-6.
3. Franklin D, Cardini A, Higgins PO, Oxnard CE, Dadour I. Mandibular morphology as an indicator of human subadult age: geometric morphometric approaches. J Forensic Sci 2008; 4: 91-99.
4. Dudar JC, Pfeiffer S, Saunders SR. Evaluation of morphological and histological adult skeletal age-at-death estimation techniques using ribs. J Forensic Sci 1993; 38:677–85.
5. Bašić Ž, Anterić I, Vilović K, Petaros A, Bosnar A, Madžar T *et al*. Sex determination in skeletal remains from the medieval Eastern Adriatic coast - discriminant function analysis of humeri. Croat Med J 2013;54:272-8.
6. Bidmos MA, Gibbon VE, Štrkalj G. Recent advances in sex identification of human skeletal remains in South Africa. S Afr J Sci S 2010;106:1–6
7. Sairam V, Potturi Gr, Praveen B, Vikas G. Assessment of effect of age, gender, and dentoalveolar changes on mandibular morphology: A digital panoramic study. Contemp Clin Dent 2018; 9:49-54.
8. Maat GJ, Maes A, Aarents MJ, Nagelkerke NJ. Histological age prediction from the femur in a contemporary Dutch sample. J Forensic Sci 2016; 51:230–7.
9. Rajkumari S, Nikitha K, Monisha S, Nishagrade S, Thayumanavan B, Murali BA. Role of Orthopantamograph in Forensic Identification: A Retrospective Study Among Chennai Population. J Pharm Bioallied Sci 2019;11: S393-S396.
10. Konigsberg L. W., Herrmann, N. P., Wescott D. J., Kimmerle, E. H. Estimation and Evidence in Forensic Anthropology: Age-at-Death. J Forensic Sci 2008;53:541–557.
11. Shaminey A, Gopika Manoharan. Gender Based Variations in Morphological Features of Mandible in Digital Panoramic Radiographs - A Comparative Study. Saudi J Oral Dent Res 2019;4: 31-47.
12. Chole R. H., Patil R. N., Balsaraf Chole, S., Gondivkar S., Gadbail A. R., Yuwanati, M. B. Association of Mandible Anatomy with Age, Gender, and Dental Status: A Radiographic Study. ISRN Radiology 2013; 1–4.
13. Joo J.K., Lim Y.J., Kwon H.B., Ahn S.J. Panoramic radiographic evaluation of the mandibular morphological changes in elderly dentate and edentulous subjects. Acta Odontologica Scandinavica 2012;71: 357–362.
14. Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: mandibular linear dimensions and angles. Am J Orthod Dentofacial Orthop 1986;90:45-51.
15. Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. J Anat 1999; 195:491–513.
16. Krisjane Z, Urtane I, Krumina G, Bieza A, Zepa K, Rogovska I. Condylar and mandibular morphological criteria in the 2D and 3D MSCT imaging for patients with Class II division 1 subdivision malocclusion. Stomatologija 2007;9:67-71
17. Morant GM, Collett M, Adyanthaya NK. A biometric study of the human mandible. Biometrika 1936; 28:84–122.
18. Hrdlicka A. Lower jaw further studies. Am J Phys Anthropol 1940; 27:383–467
19. Mangla R, Singh N, Dua V, Padmanabhan P, Khanna M. Evaluation of mandibular morphology in different facial types. Contemp Clin Dent 2011;2:200.
20. Poongodi V, Kanmani R, Anandi MS, Krithika CL, Kannan A, Raghuram PH. Prediction of age and gender using digital radiographic method: A retrospective study. J Pharm Bioall Sci 2015;7:S504-8.
21. Taleb NSA, Beshlawy ME. Mandibular Ramus and Gonial Angle Measurements as Predictors of Sex and Age in an Egyptian Population Sample: A Digital Panoramic Study. J Forensic Res 2015;6: 308.
22. Pangotra N, Chalkoo AH, Dar N. Mandibular Ramus: An Indicator for Gender Determination - A Digital Radiographic Study. Int J Sci Stud 2018;6:42-45
23. Shaminey S *et al*. Gender Based Variations in Morphological Features of Mandible in Digital Panoramic Radiographs - A Comparative Study. Saudi Journal of Oral and Dental Research 2019; 4: 31-47
24. Rad, Farzaneh & Javanshir, Bahareh & Nemati, Somayeh & Khaksari, Farnoosh & Mansoori, Raheleh & Ranjzad, Hadi & Shokri, Abbas. Evaluation of Sexual Dimorphism with Mandibular Parameters by Digital Panoramic Radiography. The Open Dentistry Journal 2020; 14:172-177
25. Saloni, Verma P, Mahajan P, Puri A, Kaur S, Mehta S. Gender determination by morphometric analysis of mandibular ramus in Sriganganagar population: A digital panoramic study. Indian J Dent Res 2020; 31:444-8.
26. Mehta H, Bhuvaneshwari S, Singh MP, Nahar P, Mehta K, Sharma T. Gender determination using mandibular ramus and gonial angle on OPG. J Indian Acad Oral Med Radiol 2020; 32:154-8
27. Ranaweera, W.G.P.E., Chandrasekara, C.M.C.T.K., Hraputhanthiri, H.D.S., De Silva, P. and Herath, L.H.M.I.M. Sex determination by mandibular ramus – a digital panoramic study. Sri Lanka Journal of Forensic Medicine, Science & Law. 2020; 11:10–19.

Received: November 29, 2023
Accepted: December 10, 2023

Corresponding author
Karthikeya Patil
E-mail: dr.karthikeyapatil@jssuni.edu.in