

Original Research Article

MORPHOMETRIC ANALYSIS OF AGE-RELATED CHANGES IN THE MANDIBLE: A STUDY ON GONIAL ANGLE AND SYMPHYSEAL HEIGHT VARIATIONS

Biswajit Borah¹, Rishik Raj Pathak², Madhurjya Chakraborty³, Gunjana Kalita⁴

¹Assistant Professor, Department of Anatomy, Kokrajhar Medical College, Kokrajhar, Assam, India

²Associate Consultant, Surgical Oncology, Health City Hospital, Guwahati, Assam, India

³Assistant Professor, Department of Dentistry, Kokrajhar Medical College and Hospital, Kokrajhar, Assam, India

⁴Dental Consultant, Eastern Cancer Group Clinic, Guwahati, Assam, India

Received : 13/03/2026
Received in revised form : 02/05/2026
Accepted : 17/05/2026

Corresponding Author:

Dr. Biswajit Borah,

Assistant Professor, Department of Anatomy, Kokrajhar Medical College, Kokrajhar, Assam, India.
Email: biswa_doc@hotmail.com

DOI:10.70034/ijmedph.2026.2.383

Source of Support: Nil,
Conflict of Interest: Nonedeclared

Int J Med Pub Health
2026; 16 (2); 2297-2302

ABSTRACT

Background: Age-related remodelling of the mandible is clinically relevant for forensic identification, prosthodontic planning, implant risk assessment and radiographic interpretation. The gonial angle and symphyseal height are accessible morphometric variables that may reflect cumulative skeletal adaptation to age, sex and dentition.

Materials and Methods: This retrospective cross-sectional study evaluated 240 digital panoramic radiographs of adults aged 20-79 years. Participants were categorized into four age groups: 20-34, 35-49, 50-64 and 65-79 years. Bilateral gonial angles were measured using tangent lines along the posterior ramus and inferior mandibular border, while symphyseal height was measured from the alveolar crest between the mandibular central incisors to the inferior mandibular border. Measurements were performed by two calibrated observers, and reliability was assessed using intraclass correlation coefficients.

Results: The overall mean gonial angle was 124.86 +/- 5.72 degrees, increasing from 121.38 +/- 4.89 degrees in the youngest group to 129.47 +/- 5.63 degrees in the oldest group ($p < 0.001$). Mean symphyseal height decreased significantly from 32.14 +/- 3.21 mm to 27.63 +/- 3.86 mm across the same age range ($p < 0.001$). Females showed a slightly larger gonial angle than males (126.02 +/- 5.48 degrees vs. 123.71 +/- 5.76 degrees, $p = 0.002$), whereas males had greater symphyseal height (31.04 +/- 3.80 mm vs. 28.92 +/- 3.94 mm, $p < 0.001$). Gonial angle correlated positively with age ($r = 0.46$, $p < 0.001$), while symphyseal height correlated negatively with age ($r = -0.51$, $p < 0.001$).

Conclusion: The mandible demonstrated measurable age-associated morphological changes, characterized by widening of the gonial angle and reduction in symphyseal height. These parameters may serve as useful adjunctive indicators in dental, forensic and geriatric assessment.

Keywords: Mandible; Gonial angle; Symphyseal height; Panoramic radiography; Morphometry; Age estimation; Forensic odontology.

INTRODUCTION

The human mandible is a dynamic craniofacial bone that continues to undergo structural remodelling after skeletal maturity. Although its gross form is established during growth, adult mandibular morphology is influenced by functional loading, masticatory muscle activity, tooth retention, alveolar bone support, systemic skeletal status and age-related changes in bone turnover. Because of its density and

anatomical durability, the mandible is frequently preserved in archaeological, forensic and clinical radiographic records, making mandibular morphometry a practical tool for biological profiling and treatment planning.^[1]

Among the many mandibular landmarks used in morphometric assessment, the gonial angle is particularly important because it represents the junction between the posterior ramus and the inferior mandibular body. It is influenced by the balance

between ramal growth, muscular traction and alveolar support. Previous radiographic and anthropometric studies have demonstrated that gonial angle values vary with sex, age and dentition status, although the direction and magnitude of these associations differ between populations and imaging methods.^[2]

Digital panoramic radiography provides a widely available method for evaluating mandibular dimensions in dental practice. Although panoramic images have inherent magnification and positional limitations, angular measurements such as the gonial angle are relatively less affected than linear measurements when the patient is properly positioned. For this reason, panoramic radiographs have been used in several age- and sex-related mandibular investigations, particularly in forensic odontology and oral radiology.^[3]

The association between mandibular morphology and age has clinical significance beyond forensic estimation. A widening gonial angle may suggest reduced masticatory muscle tonicity, altered occlusal loading, tooth loss or progressive mandibular remodelling in older adults. Conversely, a smaller or more acute angle is often associated with stronger vertical growth patterns and preserved muscular function. Population-based studies have shown that ramus height, bigonial width and gonial angle may display measurable age-related trends, supporting their use as supplementary variables rather than isolated diagnostic markers.^[4]

Symphyseal height is another clinically meaningful mandibular parameter. The symphyseal region is relevant in orthodontics, implant dentistry, genioplasty, trauma management and bone graft harvesting. Vertical height of the anterior mandible reflects the combined contribution of basal bone, alveolar bone and tooth-supporting structures. In adults, reduction in symphyseal height may occur due to alveolar resorption, periodontal destruction, tooth loss, osteoporosis-related changes or long-standing reduction in functional stimulation.^[5]

Radiographic studies of mandibular morphology have commonly focused on ramus height, condylar height, cortical width and gonial angle. However, fewer investigations have simultaneously examined angular posterior mandibular remodelling and anterior symphyseal height across age groups in the same sample. This combined evaluation is important because age-related mandibular change is not uniform; the posterior mandible may show angular remodelling, while the anterior mandible may show vertical reduction or compensatory changes depending on dentition and periodontal support.^[6]

Sexual dimorphism further complicates mandibular interpretation. Males generally have larger linear mandibular dimensions due to greater skeletal size, muscle mass and hormonal influences on bone modelling. Females may show comparatively higher gonial angle values in some populations, while linear measurements such as ramus height, bigonial width and symphyseal height are often greater in males.

These differences indicate that age-related analysis should adjust for sex to avoid overestimating or underestimating skeletal change.^[7]

Dentoalveolar status is another major determinant of mandibular form. Edentulous and partially dentate individuals may demonstrate mandibular resorption patterns that differ from dentate adults, especially in the alveolar and antegonial regions. Studies among elderly dentate and edentulous subjects have reported that tooth loss can alter cortical thickness, ramus-related parameters and mandibular angle measurements. Therefore, dentition status must be recorded when interpreting age-related morphometric findings.^[8]

The use of cone-beam computed tomography has improved three-dimensional analysis of symphyseal morphology, but panoramic radiography remains more accessible and exposes patients to lower radiation in routine dental settings. CBCT studies confirm that the mandibular symphysis has substantial anatomical variability and that accurate measurement of this region is relevant for surgical safety and treatment planning. Nevertheless, panoramic radiography remains useful for screening-level assessment when standardized measurement protocols are followed.^[9]

Existing literature shows that mandibular dimensions vary by population, imaging technique and clinical characteristics. There remains a need for integrated radiomorphometric studies that evaluate both gonial angle and symphyseal height in defined adult age groups, using reproducible digital measurement procedures. Therefore, the present study aimed to analyze age-related variations in gonial angle and symphyseal height on digital panoramic radiographs and to assess the influence of sex and dentition status on these mandibular morphometric parameters.^[10]

MATERIALS AND METHODS

Study design and setting: This retrospective cross-sectional radio morphometric study was conducted in the Department of Oral and Maxillofacial Surgery and Anatomy of a medical teaching institution. Digital panoramic radiographs acquired for routine diagnostic purposes between January 2025 and March 2026 were screened. The study was designed as a non-interventional analysis of archived radiographs, and all patient identifiers were removed before measurement.

Sample size and grouping: A total of 240 panoramic radiographs were included. The sample was stratified into four age groups with 60 radiographs per group: Group I, 20-34 years; Group II, 35-49 years; Group III, 50-64 years; and Group IV, 65-79 years. Equal representation of males and females was maintained as far as possible, with 120 males and 120 females included overall. Dentition status was categorized as dentate, partially dentate or edentulous based on the mandibular arch.

Inclusion criteria

Radiographs of adults aged 20-79 years with clearly visible mandibular borders, bilateral ramus outlines, mandibular angles and symphyseal region were included. Images were required to have adequate contrast, absence of gross distortion and proper patient positioning, as judged by symmetrical condylar and ramal appearance.

Exclusion criteria

Radiographs were excluded if they showed mandibular fractures, developmental deformities, cysts, tumors, previous orthognathic surgery, extensive mandibular reconstruction, severe positioning errors, blurred borders, incomplete visualization of the inferior mandibular margin or artifacts obscuring the symphysis or gonial region. Patients with known metabolic bone disease or history of radiation therapy to the jaws were also excluded when the information was available.

Radiographic acquisition and measurement protocol:

All radiographs were obtained using a digital panoramic unit with standardized exposure settings adjusted according to patient size. Images were exported in high-resolution format and analyzed using calibrated digital measurement software. The gonial angle was measured bilaterally by drawing one tangent along the posterior border of the ramus and another tangent along the inferior border of the mandibular body; the intersection of these lines represented the gonial angle. The mean of the right and left gonial angles was used for statistical analysis. Symphyseal height was measured as the vertical distance from the midpoint of the alveolar crest between the mandibular central incisors to the most inferior point of the mandibular symphysis. In edentulous patients, the superior reference point was taken at the most superior residual alveolar crest in the midline.

Observer calibration and reliability: Two trained observers independently measured 30 randomly selected radiographs twice at a two-week interval before final assessment. Intraobserver and interobserver reliability were evaluated using intraclass correlation coefficients. After satisfactory calibration, one observer completed all measurements, and 20% of the sample was remeasured to monitor consistency.

Statistical analysis: Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics

version 26.0. Continuous variables were expressed as mean +/- standard deviation. Categorical variables were summarized as frequency and percentage. One-way analysis of variance with Tukey post-hoc testing was used to compare age groups. Independent t-test was used for sex-wise comparisons. Pearson correlation analysis assessed relationships between age and morphometric variables. Multiple linear regression was performed to identify independent predictors of gonial angle and symphyseal height. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 240 digital panoramic radiographs fulfilled the eligibility criteria and were included in the final analysis. The study population consisted of 120 males and 120 females, with a mean age of 49.28 +/- 16.74 years. Each age group contained 60 participants. Dentate status was observed in 142 participants (59.2%), partial edentulism in 78 (32.5%) and complete edentulism in 20 (8.3%). The distribution of dentition status showed a progressive shift from dentate to partially dentate and edentulous categories with increasing age.

Observer reliability was excellent: The intraobserver intraclass correlation coefficient was 0.94 for gonial angle and 0.96 for symphyseal height, while the interobserver intraclass correlation coefficient was 0.91 and 0.93, respectively. These values indicated high reproducibility of the measurement protocol.

The overall mean gonial angle was 124.86 +/- 5.72 degrees. A statistically significant age-wise increase was observed, from 121.38 +/- 4.89 degrees in Group I to 129.47 +/- 5.63 degrees in Group IV ($p < 0.001$). Post-hoc comparison showed significant differences between Group I and Groups III and IV, and between Group II and Group IV. The overall mean symphyseal height was 29.98 +/- 4.02 mm. Symphyseal height decreased progressively across age groups, from 32.14 +/- 3.21 mm in Group I to 27.63 +/- 3.86 mm in Group IV ($p < 0.001$). Age-wise descriptive comparisons are shown in [Table 1].

Table 1: Age-wise comparison of gonial angle and symphyseal height

| Age group | n | Mean age (years) | Gonial angle (degrees) | Symphyseal height (mm) | p-value |
|-------------|----|------------------|------------------------|------------------------|---------|
| 20-34 years | 60 | 27.18 +/- 4.13 | 121.38 +/- 4.89 | 32.14 +/- 3.21 | <0.001 |
| 35-49 years | 60 | 42.21 +/- 4.17 | 123.18 +/- 5.08 | 30.72 +/- 3.54 | |
| 50-64 years | 60 | 57.06 +/- 4.19 | 125.41 +/- 5.38 | 29.43 +/- 3.71 | |
| 65-79 years | 60 | 70.68 +/- 4.02 | 129.47 +/- 5.63 | 27.63 +/- 3.86 | |

Sex-wise analysis demonstrated that females had a significantly larger mean gonial angle than males (126.02 +/- 5.48 degrees vs. 123.71 +/- 5.76 degrees, $p = 0.002$). In contrast, males showed significantly greater symphyseal height than females (31.04 +/-

3.80 mm vs. 28.92 +/- 3.94 mm, $p < 0.001$). The right and left gonial angles showed no statistically significant side difference ($p = 0.118$), supporting the use of the bilateral mean value. Sex-wise findings are presented in [Table 2].

Table 2: Sex-wise comparison of mandibular morphometric parameters

| Variable | Male (n=120) | Female (n=120) | Mean difference | p-value |
|------------------------------|-----------------|-----------------|-----------------|---------|
| Mean age (years) | 49.76 +/- 16.52 | 48.81 +/- 16.99 | 0.95 | 0.661 |
| Right gonial angle (degrees) | 123.54 +/- 5.91 | 125.86 +/- 5.62 | -2.32 | 0.003 |
| Left gonial angle (degrees) | 123.88 +/- 5.78 | 126.18 +/- 5.51 | -2.30 | 0.002 |
| Mean gonial angle (degrees) | 123.71 +/- 5.76 | 126.02 +/- 5.48 | -2.31 | 0.002 |
| Symphyseal height (mm) | 31.04 +/- 3.80 | 28.92 +/- 3.94 | 2.12 | <0.001 |

Correlation analysis demonstrated a moderate positive relationship between age and gonial angle ($r = 0.46$, $p < 0.001$) and a moderate negative relationship between age and symphyseal height ($r = -0.51$, $p < 0.001$). Gonial angle and symphyseal height were negatively correlated with each other ($r = -0.39$, $p < 0.001$), indicating that individuals with wider mandibular angles tended to have reduced anterior mandibular vertical height.

Dentition status showed a significant association with both mandibular parameters. Edentulous participants

had the largest gonial angle (130.11 ± 5.77 degrees) and the lowest symphyseal height (26.84 ± 3.58 mm), whereas dentate participants had the smallest gonial angle (123.01 ± 5.11 degrees) and greatest symphyseal height (31.22 ± 3.47 mm). Multiple regression identified age, sex and dentition status as significant predictors of symphyseal height, explaining 39.4% of its variance. For gonial angle, age and dentition status remained significant predictors, explaining 31.8% of variance. These analyses are summarized in Table 3.

Table 3: Correlation and regression analysis for morphometric variables

| Analysis | Dependent variable | Predictor/relationship | Coefficient | p-value |
|---------------------|--------------------|------------------------|--------------|---------|
| Pearson correlation | Gonial angle | Age | $r = 0.46$ | <0.001 |
| Pearson correlation | Symphyseal height | Age | $r = -0.51$ | <0.001 |
| Pearson correlation | Symphyseal height | Gonial angle | $r = -0.39$ | <0.001 |
| Multiple regression | Gonial angle | Age | Beta = 0.34 | <0.001 |
| Multiple regression | Gonial angle | Dentition status | Beta = 0.27 | 0.004 |
| Multiple regression | Symphyseal height | Age | Beta = -0.38 | <0.001 |
| Multiple regression | Symphyseal height | Sex | Beta = 0.21 | 0.002 |
| Multiple regression | Symphyseal height | Dentition status | Beta = -0.29 | <0.001 |

DISCUSSION

The present study demonstrated clear age-associated mandibular morphometric changes on digital panoramic radiographs. The gonial angle increased progressively with advancing age, while symphyseal height decreased across successive age groups. These findings suggest that posterior angular remodelling and anterior vertical reduction are interrelated features of mandibular ageing. Similar observations have been reported in radiographic studies where the gonial angle was evaluated in relation to age, sex and dentition status, supporting the concept that mandibular angle morphology reflects cumulative functional and skeletal adaptation.^[11]

The mean gonial angle in the present sample was 124.86 degrees, which falls within the range commonly reported in adult panoramic studies. The significant increase from 121.38 degrees in young adults to 129.47 degrees in older adults may be explained by age-related changes in masticatory muscle activity, occlusal force distribution and alveolar support. Ohm and Silness emphasized that tooth retention and age influence mandibular jaw angle dimensions, and their findings remain biologically relevant because tooth loss and reduced function can change the mechanical environment of the mandibular body and ramus.^[12]

Our finding that females had a larger gonial angle than males is consistent with several radiomorphometric reports. Leversha et al. observed larger gonial angles in females and greater ramus

height and bigonial width in males, suggesting that angular and linear mandibular parameters do not express sexual dimorphism in the same direction. This pattern may be attributed to differences in muscle mass, mandibular robustness and vertical facial morphology between sexes.^[13]

The observed reduction in symphyseal height with age is clinically important. The mandibular symphysis contains both basal bone and alveolar bone. With ageing, periodontal breakdown, tooth loss and residual ridge resorption may reduce the vertical component of the anterior mandible. Although panoramic radiography does not provide three-dimensional information, standardized midline height measurement can still reflect clinically meaningful anterior mandibular change. CBCT-based investigations of the symphyseal region have shown that vertical bone height and cortical dimensions vary by sex and anatomical site, reinforcing the need for individualized assessment before surgery or implant planning.^[14]

The negative correlation between gonial angle and symphyseal height in this study suggests that widening of the posterior mandibular angle is accompanied by reduction of anterior mandibular vertical dimension. This relationship is plausible because generalized reduction in dentoalveolar support can affect both posterior and anterior mandibular morphology. Joo et al. reported mandibular morphological differences in elderly dentate and edentulous subjects, highlighting the influence of dental status on angular and linear measurements in older adults.^[15]

Dentition status was a significant predictor of both gonial angle and symphyseal height. Edentulous participants showed the widest gonial angles and lowest symphyseal heights. Huuonen et al. similarly reported that edentulousness influences gonial angle, ramus height and condylar height, indicating that the absence of teeth modifies mandibular morphology beyond localized alveolar resorption. The present findings therefore support recording dentition status as a mandatory variable in mandibular age-estimation and morphometric studies.^[16]

The forensic relevance of these results lies in their potential to supplement age estimation when complete skeletal records are unavailable. However, mandibular parameters should not be used as sole age indicators because they are affected by sex, population, dental status, nutrition, parafunction and systemic bone health. Bhuyan et al. demonstrated that panoramic radiographic mandibular measurements may assist age and sex estimation, but such applications require population-specific standards and combined-variable models rather than reliance on one measurement.^[17]

Recent postmortem and radiographic morphometric research has further emphasized that mandibular variables should be interpreted through combined anatomical, demographic and functional models, and the present findings support a multifactorial approach to clinical and forensic interpretation.^[18]

The strengths of this study include a balanced age-group design, equal sex distribution, standardized digital measurements and reliability testing. The use of both angular and linear parameters allowed simultaneous evaluation of posterior and anterior mandibular ageing. Nevertheless, limitations must be acknowledged. The retrospective design limited control over systemic health variables and duration of edentulism. Panoramic radiography may introduce magnification in linear measurements, although standardized acquisition and exclusion of distorted images minimized this effect. Future studies should compare panoramic findings with CBCT measurements, include bone density assessment and develop multivariable prediction equations for age estimation in specific populations.

CONCLUSION

The present morphometric study showed that adult mandibular morphology changes significantly with age. Gonial angle increased progressively across age groups, while symphyseal height decreased, indicating that posterior angular remodelling and anterior vertical reduction are important features of mandibular ageing.

Sex and dentition status influenced these parameters. Females demonstrated slightly larger gonial angles, whereas males had greater symphyseal height. Edentulous individuals showed the widest gonial angles and lowest symphyseal heights, confirming

the role of dentoalveolar support in maintaining mandibular form.

Gonial angle and symphyseal height may serve as useful adjunctive variables in forensic odontology, geriatric dental assessment and clinical treatment planning. However, they should be interpreted along with sex, dentition status and population-specific standards rather than as independent age indicators.

REFERENCES

1. Upadhyay RB, Upadhyay J, Agrawal P, Rao NN. Analysis of gonial angle in relation to age, gender, and dentition status by radiological and anthropometric methods. *J Forensic Dent Sci.* 2012;4(1):29-33. doi: 10.4103/0975-1475.99160.
2. Chole RH, Patil RN, Balsaraf Chole S, Gondivkar S, Gadail AR, Yuwanati MB. Association of mandible anatomy with age, gender, and dental status: a radiographic study. *ISRN Radiol.* 2013;2013:453763. doi: 10.5402/2013/453763.
3. Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: mandibular linear dimensions and angles. *Am J Orthod Dentofacial Orthop.* 1986;90(1):45-51. doi: 10.1016/0889-5406(86)90026-0.
4. Shah PH, Venkatesh R, More CB, Vaishnav V. Age- and sex-related mandibular dimensional changes: a radiomorphometric analysis on panoramic radiographs. *Indian J Dent Res.* 2020;31(1):113-117. doi: 10.4103/ijdr.IJDR_327_18. PMID: 32246692.
5. Salemi F, Farhadian M, Ebrahimi M. Anatomical variations of the mandibular symphysis in a normal occlusion population using cone-beam computed tomography. *J Dent Res Dent Clin Dent Prospects.* 2021;15(3):179-185. doi: 10.34172/joddd.2021.032. PMID: 34621345.
6. Joo JK, Lim YJ, Kwon HB, Ahn SJ. Panoramic radiographic evaluation of the mandibular morphological changes in elderly dentate and edentulous subjects. *Acta Odontol Scand.* 2013;71(2):357-362. doi: 10.3109/00016357.2012.690446. PMID: 22774938.
7. Leversha J, McKeough G, Myrteza A, Skjellrup-Wakefield H, Welsh J, Sholapurkar A. Age and gender correlation of gonial angle, ramus height and bigonial width in dentate subjects in a dental school in Far North Queensland. *J Clin Exp Dent.* 2016;8(1):e49-e54. doi: 10.4317/jced.52683.
8. Huuonen S, Sipila K, Haikola B, Tapio M, Soderholm AL, Remes-Lyly T, et al. Influence of edentulousness on gonial angle, ramus and condylar height. *J Oral Rehabil.* 2010;37(1):34-38. doi: 10.1111/j.1365-2842.2009.02022.x. PMID: 19912483.
9. Lee JE, Lee YJ, Jin SH, Kim Y, Kook YA, Ko Y, et al. Topographic analysis of the mandibular symphysis in a normal occlusion population using cone-beam computed tomography. *Exp Ther Med.* 2015;10(6):2150-2156. doi: 10.3892/etm.2015.2842. PMID: 26668608.
10. 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(1):49-54. doi: 10.4103/ccd.ccd_704_17. PMID: 29599584.
11. Larrazabal-Moron C, Sanchis-Gimeno JA. Gonial angle growth patterns according to age and gender. *Ann Anat.* 2018;215:93-96. doi: 10.1016/j.aanat.2017.09.004. PMID: 28954210.
12. Ohm E, Silness J. Size of the mandibular jaw angle related to age, tooth retention and gender. *J Oral Rehabil.* 1999;26(11):883-891. doi: 10.1046/j.1365-2842.1999.00464.x. PMID: 10583739.
13. Mangla R, Singh N, Dua V, Padmanabhan P, Khanna M. Evaluation of mandibular morphology in different facial types. *Contemp Clin Dent.* 2011;2(3):200-206. doi: 10.4103/0976-237X.86458. PMID: 22090762.
14. Lee KA, Kim MS, Hong JY, Lee JS, Park JB, Kim YI, et al. Anatomical topography of the mandibular symphysis in the Korean population: a computed tomography analysis. *Clin Anat.* 2014;27(4):592-597. doi: 10.1002/ca.22315.

15. Dutra V, Devlin H, Susin C, Yang J, Horner K, Fernandes AR. Mandibular bone remodelling in adults: evaluation of panoramic radiographs. *DentomaxillofacRadiol*. 2004;33(5):323-328. doi: 10.1259/dmfr/17685970.
16. Xie Q, Wolf J, Ainamo A. Quantitative assessment of vertical heights of maxillary and mandibular bones in panoramic radiographs of elderly dentate and edentulous subjects. *Acta Odontol Scand*. 1997;55(3):155-161. doi: 10.3109/00016359709115410.
17. Bhuyan R, Mohanty S, Bhuyan SK, Pati A, Priyadarshini S, Das P. Panoramic radiograph as a forensic aid in age and gender estimation: preliminary retrospective study. *J Oral Maxillofac Pathol*. 2018;22(2):266-270. doi: 10.4103/jomfp.JOMFP_90_17. PMID: 30158784.
18. Hamza NC, Gupta C, Palimar V. Morphometric measurements of mandible to determine stature and sex: a postmortem study. *J Taibah Univ Med Sci*. 2024;19(1):160-167. doi: 10.1016/j.jtumed.2023.09.007.