

## ANALYSIS OF GONIAL ANGLE VARIATIONS IN BATAKNESE INDIVIDUALS BASED ON GENDER AND DENTAL CONDITION USING PANORAMIC RADIOGRAPHY

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### ABSTRACT

**Introduction:** Panoramic radiography provides a comprehensive view of the jaws and is valuable for assessing mandibular morphology, including the gonial angle. **Aim:** This study aimed to analyze differences in the gonial angle related to dental status and gender within a Batakese population. **Method:** An observational analytical study was conducted from June 2022 to July 2023. A total of 120 panoramic radiographs from Batakese individuals were collected via purposive sampling at the Dental Radiology Installation of the Dental Hospital, Universitas Sumatera Utara, and the Pramita Medan Clinic Laboratory. The sample comprised 60 dentate subjects (control group) and 60 partially edentulous subjects. The gonial angle was measured on each radiograph. Data were analyzed using descriptive statistics and independent samples *t*-tests, with statistical significance set at  $p < 0.05$ . **Results:** The mean gonial angle in partially edentulous men was  $119.942^\circ$ , compared to  $123.367^\circ$  in women. In the dentate group, the mean angle was  $117.497^\circ$  for men and  $121.335^\circ$  for women. Women had a larger angle than men in both groups. However, no statistically significant difference was found between genders within the partially edentulous group, or between dentate and partially edentulous subjects when analyzed separately by gender. **Conclusion:** Partial tooth loss was associated with a larger gonial angle in this Batakese sample, and angles were consistently greater in women. Gender alone did not show a significant effect within the partially edentulous condition.

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### INTRODUCTION

Dental radiography plays a crucial role as a complementary diagnostic tool in dental treatment planning. Among the various radiographic techniques, panoramic radiography

is one of the most widely employed due to its accessibility and ability to provide a comprehensive view of the maxillofacial region. This modality enables detailed visualization of the entire dentition and adjacent anatomical structures, including the mandibular gonial angle, making it a valuable tool in routine dental practice.<sup>1-3</sup> The ramus line and the mandibular line, which are tangential to the inferior border of the mandible, and the ramus line at the condyle

and the ramus, respectively, produce the mandibular angle, also known as the gonial angle of the mandible.<sup>4</sup> From an aesthetic standpoint, the mandibular gonial angle plays a significant role in the harmonious facial profile.<sup>5</sup> A crucial mandibular marker, the gonial angle, is frequently used in forensics to identify age, race, and gender.<sup>6,7</sup> Age and dental health are considered to have an impact on alterations in the mandibular gonial angle.<sup>4</sup>

Edentulism is a disorder characterized by the absence or reduction of natural teeth in the mouth.<sup>8</sup> If left untreated, tooth loss may progress to complete edentulism. This condition can result from a multifactorial etiology, including trauma, dental caries, iatrogenic interventions, congenital anomalies, and periodontal disease. Edentulism refers to the complete or partial loss of natural teeth, and the standard treatment approach typically involves the fabrication of removable, tissue-supported full dentures.<sup>9-11</sup> The mandibular gonial angle may widen, and the masticatory muscles may become less effective as a result of tooth loss.<sup>4,12,13</sup> Edentulism contributes to morphological alterations of the mandible, including an increase in the gonial angle and a reduction in the height of both the condyle and the mandibular ramus, as reported by Dewangan et al. These structural changes may lead to diminished function of the masticatory muscles. Consequently, preserving masticatory muscle activity and rehabilitating the mastication system are essential aspects of managing patients with edentulism.<sup>4</sup> The gonial angle in North Indian people has been found to positively

correlate with age in a study by Bathla et al., with an increase in mean value as age increases.<sup>5</sup>

Using panoramic radiography, Joo et al.'s study examined changes in bone thickness, condyle and ramus height, and jaw angle in South Korea. According to the findings, women had a bigger jaw angle than men did, and those who had lost every tooth also had a larger jaw angle.<sup>12</sup> However, there was no discernible variation in the jaw angles of the edentulous, old dentate, and young dentate participants in Oksayan et al.'s study.<sup>14</sup> The most popular kind of extraoral radiography procedure is panoramic radiography, offering comprehensive visualization of the hard tissues in both the maxilla and mandible.<sup>5,15</sup> On a video, it presents a picture of the face, including the lower and upper jaw arches, their supporting structures, and the full dentition.<sup>2,3</sup>

According to a study by Bhullar et al., panoramic radiography can measure the mandibular gonial angle just as accurately as lateral cephalometric radiography. One benefit of panoramic radiography is that it shows the left and right gonial angles independently, which facilitates measurement.<sup>16,17</sup> The rationale behind the Bataknese study is that a set of closely related Austronesian ethnic groups, mostly located in North Sumatra, are collectively referred to as Batak. Toba, Karo, Mandailing, Pakpak, and Simalungun are the five ethnic groups. This study used panoramic radiography to compare the gonial angle of the mandible between the gender-based groups of partially edentulous and dentate Bataknese people.

## METHODS

This study was observational-analytical and employed a cross-sectional technique. The study was conducted at the Dental Radiology Installation of the Dental and Oral Hospital, Universitas Sumatera Utara, and the Clinical Laboratory Pramita Medan. The Health Research Ethics Committee of Universitas Sumatera Utara has approved the current study with letter 37/KEPK/USU/2023. The current study was carried out between June 2022 and July 2023.

The sample selection strategy employed for this study was purposeful sampling. A total of 120 panoramic radiographs were obtained for this investigation; 60 of these pictures showed dentate individuals, and the other 60 showed somewhat edentulous participants. To ensure that the analysis of the selected radiographic image quality does not introduce bias into the calculation results, a blind review with two observers and a reliability analysis was performed.

The study required panoramic radiographs of Bataknese individuals between the ages of 20 and 40 that displayed the gonial angle structure of the mandible, as well as dentures of acceptable quality, and those who had lost two to four posterior mandibular teeth on one side of the jaw. Along with muscular changes, the gonial angle—particularly the TMJ—will exhibit several changes at this age. Panoramic radiographs of patients with mandibular fractures who have had jaw surgery or other therapies were excluded from the study. Panoramic radiographs were taken using a digital sensor system and panoramic radiography equipment. Using ImageJ

software, the mandibular gonial angle was measured and analyzed on panoramic radiography results at the junction of the ramus and mandibular lines. At the mandible's lower border, a mandibular line is drawn. The mandibular condyle and the distal boundary of the ramus are where the ramus line is drawn (Figure 1). To avoid bias, a reliability test with two observers using the kappa coefficient was used, with substantial agreement results. Calculate the gonial angle, which is the angle created by the intersection of these two lines.<sup>18</sup> An independent T-test was used for data processing and analysis, and a value is considered statistically significant if it exceeds  $p < 0.05$ .

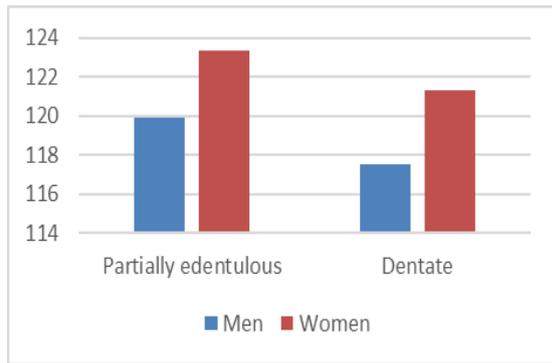


Figure 1. The mandibular gonial angle measurement

## RESULTS

Dentate men had the lowest mean mandibular gonial angle, measuring  $117.497^\circ$ , while somewhat edentulous women exhibited the highest mean gonial angle, at  $123.367^\circ$  (Figure 2). This finding suggests a possible association between dental status and changes in mandibular morphology, with edentulism potentially contributing to a wider gonial angle. The smallest mean value of the gonial angle was found in full-dentate men; the largest gonial angle of the mandible was found in women with partial teeth (Table 1). These findings suggest that both

gender and dental status may influence the gonial angle.



**Figure 2.** Based on gender, the mean mandibular gonial angle value was higher in participants who were partially edentulous and dentate. Statistically significant results for full dentate between men and women

Men's mandibular gonial angles in patients with partial tooth loss averaged 119.942°, while those with full denture values were recorded at 117.497°. Analysis using an independent T-test with a 95% degree of significance yielded a value of  $p < 0.05$ , indicating a significant difference.

Women's mean mandibular gonial angle values differed insignificantly between patients with partial tooth loss (mean value, 123°) and those with full dentures (mean value, 121°), as determined by an independent t-test with a 95% degree of significance. A value of  $p > 0.05$  was obtained (Table 2).

In completely dentate patients, the mean gonial angle of the mandible was 121.335° in women and 117.497° in men. A 95% degree of significance independent T-test analysis yielded results with a value of  $p < 0.05$  in patients with complete dentate teeth. These findings demonstrate statistically significant variations between men and women in the mean gonial angle of the mandible among complete dentate patients (Table 3).

**Table 1.** Based on gender, the mean mandibular gonial angle value in individuals with full dentate and partial tooth loss

Dental status	Gender	n	Left		Right		Total
			Mean	Standard Deviation	Mean	Standard Deviation	
Full dentate	Men	30	117.520	4.591	117.474	3.874	117.497 ± 3.644
	Women	30	120.060	3.515	122.609	6.244	121.335 ± 4.621
Partial tooth loss	Men	30	120.596	9.518	118.997	7.435	120.114 ± 8.430
	Women	30	123.840	5.988	124.353	4.073	123.785 ± 5.041

**Table 2.** The variation in the mean mandibular gonial angle between males and females in patients with complete dentate versus partial tooth loss

Gender	Dental status	Mean	Standard Deviation	p-value
Men	Partial tooth loss	120.114	8.430	0.284 <sup>a</sup>
	Full dentate	117.497	3.644	
Women	Partial tooth loss	123.785	5.041	0.176 <sup>a</sup>
	Full dentate	121.335	4.621	

a. Independent T-test

**Table 3.** The gender-based variation in the mean mandibular gonial angle value in persons with partial dentate and edentulous teeth

Dental status	Gender	Mean	Standard Deviation	p-value
Partial tooth loss	Men	120.114	8.430	0.185 <sup>a</sup>
	Women	123.785	5.041	
Full dentate	Men	117.497	3.644	0.013 <sup>a</sup>
	Women	121.335	4.621	

a: Independent t-test

## DISCUSSION

The maxilla, mandible, and dentition are all extensively covered by a panoramic radiograph, including the mandibular gonial angle area, which is measured in this study.<sup>19</sup> A control group was included in this study to evaluate potential differences in the mandibular gonial angle between partially edentulous and dentate Batakese individuals across gender groups. The mandible, recognized as the largest and most robust bone in the craniofacial complex, comprises two main components: the mandibular corpus and the mandibular ramus. The intersection of these two anatomical structures forms the mandibular gonial angle.<sup>20</sup> One change in mandibular morphology that may occur in edentulous patients is in the gonial angle of the jaw.<sup>4,12</sup>

Graph 1 illustrates that the mean mandibular gonial angle is generally higher in the partially edentulous group compared to the dentate group. According to studies by Dewangan et al., Oksayan et al., and Basheer et al., the mandibular gonial angle is larger in the group of those who are somewhat edentulous than in those who are dentate. Because it is linked to the reduced

masticatory muscle function brought on by edentulism, this outcome may transpire.<sup>4,12,14</sup>

One of the ways that edentulism can alter the mandible's morphology is by causing the mandibular gonial angle to broaden.<sup>4,12</sup> The mandibular gonial angle is anatomically formed at the junction between the most posterior margin of the mandibular ramus and the inferior border of the mandibular body. In edentulous individuals, the reduction in occlusal mechanical stimulation can diminish masticatory muscle activity. The gonial angle region serves as an attachment site for key masticatory muscles, including the masseter and medial pterygoid. The shape of the mandibular bone is influenced by the contraction force of these muscles. In the absence of occlusal contact due to tooth loss, the functional activity of the masseter and medial pterygoid muscles declines, which may contribute to an increase in the gonial angle.<sup>4,12,14,21</sup>

Figure 2 reveals that the mean mandibular gonial angle is consistently higher in female Batakese individuals compared to their male counterparts, across both dental status categories. In the partially edentulous group, females exhibited a mean

gonial angle of  $123.367^\circ$ , whereas males showed a mean of  $119.942^\circ$ . In the fully dentate group, the mean gonial angle was  $121.335^\circ$  in females and  $117.947^\circ$  in males. These findings suggest a gender-based anatomical variation in mandibular morphology, irrespective of dental status. Research by Basheer et al. and Joo et al., which discovered that women with both partial edentulous and dentate conditions had higher mean values of mandibular gonial angles than men, supports this conclusion<sup>12,20</sup> According to research by Joo et al., men's mandibular gonial angles are 3-5° smaller than women's.<sup>12</sup> Prior research, including participants from other nations, revealed variations in the mean value of mandibular gonial angles.<sup>4,14,21</sup>

The observed variations in gonial angle measurements may be influenced by a combination of genetic, environmental, behavioral, and ethnic factors. This study specifically involved participants of Bataknese ethnicity, an Austronesian ethnic group predominantly residing in North Sumatra, Indonesia. The Bataknese population—comprising subgroups such as Batak Toba, Karo, Simalungun, Pakpak, Angkola, and Mandailing—is classified within the Mongoloid or proto-Malay racial group. Distinct craniofacial features commonly identified in this population include a broad and square-shaped skull, a rectangular facial structure, and a relatively wide mandibular region.<sup>22-24</sup> Because

anatomical variances often adapt to the environment and habits, any individual with a varied environment and a variety of habits will have anatomical variations. People have a wide range of morphological variants as a result of these influences, which cause morphological adaptations that usually transmit distinct morphological features.<sup>25</sup>

Table 2 presents the results of the independent T-test analysis, indicating that the mean mandibular gonial angle in male participants did not differ significantly between the partially edentulous group ( $119.942^\circ$ ) and the dentate group ( $117.497^\circ$ ), with a p-value of 0.307 ( $p > 0.05$ ). Similarly, no statistically significant difference was observed in female participants between the dentate group ( $121.335^\circ$ ) and the partially edentulous group ( $123.367^\circ$ ), with a p-value of 0.263 ( $p > 0.05$ ). These results suggest that, within both male and female Bataknese individuals, dental status (dentate vs. partially edentulous) does not significantly influence the gonial angle of the mandible. These findings, however, conflict with those of a study by Dewangan et al., which discovered that partially edentulous men had a higher mandibular gonial angle than dentate men with statistically significant differences.<sup>4</sup> The mandibular gonial angle of partially edentulous women is larger than that of dentate women with substantial variations, according to research by Basheer et al.<sup>21</sup> Reasons that may support these study

findings include the possible differences in the population used in this study, different research methods, such as different techniques for measuring the mandibular gonial angle, and environmental factors, such as diet or chewing habits, which can influence the mandibular gonial angle and vary between populations.

Table 3 of the current study demonstrates that there is a difference between men and women in the Batakese group with partial edentulous mandible gonial angle, with women having a larger gonial angle than men. An independent T-test used in statistical analysis produced a significance value of 0.185 ( $p > 0.05$ ), indicating that the observed difference was not statistically significant. This is consistent with studies by Basheer et al. and Fouda et al. that showed no discernible variation in the mandibular gonial angle according to gender.<sup>21,26</sup> Nonetheless, this study found that women had a higher mean mandibular gonial angle than men did. According to Table 3 of the current study, women in Batakese have a bigger gonial angle of the mandible than men, and there is a difference in the mandibular gonial angle of the dentate group between the sexes. An independent T-test statistical analysis revealed a significant difference with a significance value of 0,013 ( $p < 0.05$ ). The non-statistically significant results for partial dentition between men and women may be due to the relatively small differences in partial dentition between men

and women, which may lead to the study failing to detect a statistically significant difference. Other confounding factors, such as age, health status, or dental health behaviors, may also influence the results, which may lead to the study failing to detect a statistically significant difference between men and women. Statistically significant results for complete dentition between men and women may be due to biological, environmental, genetic, and behavioral factors. Men and women have biological differences that can affect dental development and health. For example, sex hormones such as estrogen and testosterone can influence tooth development and bone structure. Men and women may have differences in lifestyle and environmental factors that can affect dental health. For example, men may be more likely to smoke and consume alcohol, which can increase the risk of tooth decay. Men and women have genetic differences that can affect dental development and health. For example, some studies have found that women are more likely to have smaller and straighter teeth than men. Men and women may differ in dental health behaviors, such as frequency of tooth brushing and dental visits. For example, women may be more likely to have better dental health practices than men.

Men have larger bones than women, on average, but other factors besides gender also affect bone size and thickness, like eating a healthier diet and engaging in

intense physical activity. Men also tend to have higher testosterone levels. This hormone enhances protein synthesis, thereby accelerating the formation of the bone's organic matrix by osteoblasts during mineralization. As a result, bone growth and mass development are typically greater in men compared to women.<sup>27,28,29</sup> Abuhijleh et al. suggested that the difference might also be caused by the influence of masticatory forces since people with larger masticatory forces tend to have smaller gonial angles. Age-related issues may be the reason for the study's negligible differences. Studies by Dewangan et al. and Basheer et al. used participants of various ages, including the elderly.<sup>4,21</sup> According to Bathla et al., as people age, their mandibular gonial angle tends to enlarge. Around the age of 20, the process of bone production becomes quite active and outpaces the process of bone resorption in young individuals. Between the ages of 20 and 40, both the processes of bone production and resorption are equally active.<sup>30</sup> Greater resorption and less masticatory muscle action can occur as people age, allowing for more mandibular alterations.<sup>30</sup>

Furthermore, the quantity of teeth present may also have an impact on the negligible variation in the outcome. Dewangan et al. discovered a substantial negative correlation between the mandibular gonial angle and the number of teeth present. The mandibular gonial angle increases with

the number of teeth lost or the number of teeth remaining in a patient.<sup>4</sup> Oettle et al. discovered that participants with unequal tooth distribution and lost molar teeth had the most obtuse mandibular gonial angle, whereas subjects with molars and even distribution on both sides had the most acute angle. The masticatory system distributes occlusal stresses more evenly when all of the molars are still in place, resulting in a reduced mandibular gonial angle.<sup>25</sup> According to Abuhijleh et al., panoramic radiography is now recognized as a trustworthy method for determining the mandible's gonial angle in addition to lateral cephalometric radiography.<sup>27</sup> The gonial angle of the mandible can be ascertained using lateral cephalometry. However, because lateral cephalometry images of anatomical components overlap, this approach presents challenges in measuring individual gonial angles.<sup>17</sup>

According to Bhullar et al., panoramic radiography offers an overview of the gonial angle area of the right and left jaw without any anatomical overlap, making it an excellent option for measuring the mandibular gonial angle.<sup>16</sup> Compared to lateral cephalometry, panoramic radiography is a more straightforward method of determining the mandibular gonial angle because the measurements made on a dry mandible are almost identical. Thus, for measuring the mandibular gonial angle, panoramic radiography might be a

better choice.<sup>31</sup> However, panoramic radiography has limitations that need to be considered, such as image distortion, especially in areas not parallel to the focal plane, superimposition (overlapping images between different structures), and poor image quality, especially if the patient cannot stand properly or if there is equipment interference. Therefore, a careful evaluation is necessary before performing panoramic radiography.

## CONCLUSION

When Batakese men and women experience partial tooth loss, their gonial angle is larger than that of those with full dentures. Compared to Batakese men, women have a greater gonial angle.

## REFERENCES

1. Raidha F, Epsilawati L, Wardani R. Radiography knowledge in dentistry for high school students. *Padjadjaran J Dent Res Student* 2018;2(2):150–4.
2. Whaites E, Drage N. *Essentials of dental radiography and radiology*. 5th ed. Edinburgh: Churchill Livingstone Elsevier, 2013;
3. Iannucci JM, Howerton LJ. *Dental radiography*. 5th ed. St. Louis: Elsevier, 2017;
4. Dewangan A, Dewangan D, Tiwari M, et al. The effect of dentate, partial dentate, and non-dentate jaw on mandibular morphology radiographic retrospective study. *International Journal of Medical Science and Current Research (IJMSCR)* 2018;1(1):172–9.
5. Bathla S, Srivastava S, Sharma R, Chhabra S. Influence of age on the radiomorphometric indices of the gonial region of mandible in North-Indian population. *J Med and Dent Sci* 2014;3(2):411–20.
6. Panneerselvam E, Prasad PJ, Balasubramaniam S, Somasundaram S, Raja KVB, Srinivasan D. The influence of the mandibular gonial angle on the incidence of mandibular angle fracture—a radiomorphometric study. *Journal of Oral and Maxillofacial Surgery* 2017;75(1):153–9.
7. Alfawzan AA. Gonial angle as a determinant of gender, a panoramic study in a sample of Saudi Population. *Indian J Public Health Res Dev* 2020;11(1):1689–93.
8. Anshary MF, Cholil AI. Description of the pattern of partial tooth loss in the community of Guntung Village, Ujung, Banjar Regency. *Dentino J Ked Gi* 2014;2(2):138–43.
9. Kailembo A, Preet R, Stewart Williams J. Common risk factors and edentulism in adults, aged 50 years and over, in China, Ghana, India and South Africa: results from the WHO Study on global AGEing and adult health (SAGE). *BMC Oral Health*. 2017; 17(1): 29.
10. Ulfa W, Amalia R, Santoso AS. The relationship between tooth loss and pre-elderly nutritional status and quality of life. *Dent J*. 2023; 56(2): 80–6.
11. Prathivi HK, Sari R. Creeping attachment post-gingival recession treatment using a vestibular incision subperiosteal tunneling access technique combined with a connective tissue graft. *Dent J* 2023; 56(1): 13–6
12. Joo JK, Lim YJ, Kwon HB, Ahn SJ. Panoramic radiographic evaluation of the mandibular morphological changes in elderly dentate and dentulous subjects. *Acta Odontol Scand* 2013;71(2):357–62.
13. Rozylo-Kalisnowska I. Panoramic radiography in dentistry. *Clin Dent Rev* 2021;5(26):1–10.
14. Okşayan R, Asarkaya B, Palta N, Şimşek İ, Sökücü O, İşman E. Effects of Edentulism on Mandibular Morphology: Evaluation of Panoramic Radiographs. *The Scientific World Journal* 2014;2014:1–5.
15. Chusida AN, Kurniawan A, Rizky BN, Pribadi SN, Diva AT, Anandhiyah HD, Alias A. Gonial angle and mandibular ramus height in Surabaya population: comparison and correlation analysis in panoramic radiograph. *Dent J* 2024;10(2):116–22.
16. Bhullar MK, Uppal AS, Kochhar GK, Chachra S, Kochhar AS. Comparison of gonial angle determination from cephalograms and orthopantomograms. *Indian J Dent* 2014;5(3):123–6.

17. Katti G, Katti C, Karuna, Shahbaz S, Khan M, Ghali SR. Reliability of panoramic radiography in assessing gonial angle compared to lateral cephalogram in adult patients with class I malocclusion. *J Indian Acad Oral Med Radiol* 2016;28:252–5.
18. Rajak RRK, Shrestha RM, Koju S. Reliability of panoramic radiography in assessing gonial angle compared to lateral cephalogram in patients with class I malocclusion. *Taiwan J Orthod* 2021;33(2):53–9.
19. Mallya SM, Lam EWN. *White and Pharoah's oral radiology principles and interpretation*. 8th ed. St. Louis: Elsevier, 2019;
20. Nelson SJ, Wheeler R. *Wheeler's dental anatomy, physiology and occlusion*. 10th ed. St. Louis: Elsevier, 2015;
21. Basheer B, Muharib S Bin, Moqbel G Bin, et al. Mandibular morphological variations in partially edentulous adult patients: an orthopantomographic study. *Int J Med Res Health Sci* 2019;8(11):67–74.
22. Lumban Gaol MN. Cephalometry Variation of Bataknese. *Berkala Ilmiah Biologi* 2022;13(1):15–23.
23. Rivani Ri, Syukriani FY, Rusman AA, Linasari D. Comparison of cephalic index between Batak and Sundanese Population in Bandung. In: *Proceedings of the Annual Scientific Meeting*. Pekanbaru: Indonesian Forensic Doctors Association, 2017; p. 245–51.
24. Junitha IK, Carolina Y. Allelic diversity and discriminatory power of five microsatellite loci in autosomal DNA of Batak people in Denpasar and Badung. *Indonesian Journal of Legal and Forensic Sciences* 2016;6(6):6–10.
25. Oettle AC, Ehlers R, Steyn M. Changes in the mandibular angle during adulthood in South Africans. *American Journal of Human Biology* 2016;28(5):681–6.
26. Fouda SM, Gad MM, Tantawi M El, Virtanen JI, Sipila K, Raustia A. Influence of tooth loss on mandibular morphology: a cone-beam computed tomography study. *J Clin Exp Dent* 2019;11(9):14–9.
27. Abuhijleh E, Warreth A, Qawadi M, et al. Mandibular Gonial Angle Measurement as a Predictor of Gender—a digital panoramic study. *Open Dent J* 2019;13(1):399–404.
28. Elfitri T, Firdaus, Iswani R. Analysis of the size of the mandibular gonial angle based on panoramic X-ray results for gender identification in the Minang Tribe. *Jurnal B-Dent* 2017;4(1):15–22.
29. Ginting R, Simbolon DLH. Correlation of the vertical dimension of occlusion with five distances between facial landmarks among those of Batak Toba ethnicity. *Dent J* 2020;53(1):30–5.
30. Puspitadewi SR, Wulandari P, Kusdhany LS, Masulili SLC, Iskandar HB, Auerkari EI. Relationship of age, body mass index, bone density, and menopause duration with alveolar bone resorption in postmenopausal women. *Pesqui Bras Odontopediatria Clin Integr* 2019;19(1):1–10.
31. Parate AS, Chokotiya H, Sharma D, Sonwane S, Sharma P, Shrivastava S. Comparative evaluation of the external gonial angle in adult patients with class I malocclusion from panoramic radiographs and lateral cephalograms. *J Res Med Dent Sci* 2020;8(3):157–62.