

**How to Cite:**

Shrimali, S., Parikh, N., Nandini, C., Hemal, J., Dave, J., & Bajaj, S. (2022). Age & gender determination using bigonial width & gonial angle in panoramic radiographs. *International Journal of Health Sciences*, 6(S1), 3051–3064. <https://doi.org/10.53730/ijhs.v6nS1.5301>

# Age & Gender Determination Using Bigonial Width & Gonial Angle in Panoramic Radiographs

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**Abstract**--Background: Age & Gender determination is a crucial part of forensic researches & investigations. Mandibular parameters, condyle and ramus, in particular have been proved to show a high sexual dimorphism with respect to the development growth patterns and rates. Panoramic radiographs are often used in daily routine dental practices to assess mandibular and maxillary essential structures. The present study is conducted to assess the variations seen in measurements of gonial angle and bigonial width of mandible with age and gender. Materials & Methods: Study comprises randomly selected 200 OPG (100 male, 100 Female) dentate age range from 11 to 80 years from Oral Medicine & Radiology Department. Any defect, anomaly were ruled out. Sample was divided into seven age

groups. Bigonial angle and Gonial Angle were digitally measured. The collected data from the subjects were analysed using the SPSS version 25. Independent *t*-test, Paired *t*-test, one-way ANOVA and Discriminant analysis were used for comparison. Parameters were studied according to gender, side and different age groups. Results: Females have significantly larger value of gonial angle than males, but lower bigonial width. (*p*-value=0.00) Males have low value of gonial angle, but longer bigonial width than female (*p*-value=0.00). There are no significance changes seen with increasing age. However, with discriminant analysis, 65 % of the males and 79 % of the females were correctly classified according to the prediction equation and the overall correct classification was 71.5 %. Bigonial width alone discriminated the gender 68 % accurately, right gonial angle 71% and left gonial angle 67%. Conclusion: The findings from the present study are encouraging and show that studying bigonial width and gonial angle for gender prediction can be a useful tool in forensic investigations.

**Keywords**---Panoramic radiographs, Age and Gender Determination, Bigonial width, Gonial angle.

## Introduction

Forensic odontology is a field of dentistry that deals with issues of human identification by the use of dental evidence.<sup>1</sup> The identification method begins with gender prediction followed by the age and stature determination, as both factors are correlated to the gender. The accuracy of gender prediction depends on the number of bone fragments and parts of skeletons that are available for examination. The skull, pelvis, and femora are the most crucial anatomy for radiological gender determination.

Mandible is largest and strongest bone of the skull. Mandibular condyle and ramus, in particular have been proved to show a high sexual dimorphism with respect to the development growth patterns and rates.<sup>2</sup> Masticatory forces which are different in both the genders, affect the form and dimensions of mandibular ramus which thus affect the anatomical landmarks of the mandible. The remodelling in the gonial angle, antegonial angle, mental foramen, mandibular foramen and mandibular canal of the mandible occurs throughout the life with age, gender and dental status.<sup>3</sup>

Panoramic radiographs are often used in daily routine dental practices to assess mandibular and maxillary essential structures. Numerous mandibular indices based on panoramic radiographs, image processing and analysing techniques have been develop to allow quantification of mandibular bone, in addition, these radiographs allow a bilateral view and are adequate to inform on vertical measurements of the mandible.

The present study is conducted to assess the variations seen in measurements of gonial angle and bigonial width of mandible with age and gender. Also, the

present study aimed at evaluating the utility of gonial angle and bigonial width of mandible as a forensic tool in age estimation and gender prediction.

## **Materials and Methods**

A retrospective study was conducted at Karnavati School of Dentistry. The present study evaluated 200 randomly selected panoramic images of patients visiting the OPD, captured for various diagnostic purposes. The radiographs were captured on Soredox X-Mind Pano cepD+ machine using Digora software (Version 2.7, Windows 7 OS). The radiographs of subjects were taken at standard kilovoltage peak (kVp), milliamperage (mA), and exposure time (seconds) setting as recommended by the manufacture, i.e., 73 kVp, 10mA and 17.6 S. Around 200 participants from age group 11 to 80 years comprising of 100 males & 100 females were included in this study.

### ***Inclusion criteria***

- Panoramic radiographs of dentulous & partially edentulous
- High quality radiographs with minimal artifacts and correct patient positioning were selected for evaluation.

### ***Exclusion criteria***

- Panoramic radiographs with artifacts and positioning errors.
- Completely edentulous & pediatric patients
- Any pathology involving mandibular jaw, fractures, developmental disturbances.

The sample was divided into seven groups. Group A: 11–20 years, Group B 21–30 years, Group C 31–40 years, Group D 41–50 years, Group E 51–60 years, Group F 61–70 years and Group G 71–80 years.

## **Bigonial width**

The most inferior, posterior and lateral point on the external mandibular angle is known as Gonian and the distance between both Gonias [Gonial angles (Go)] is known as the bigonial width. It was measured horizontally from the right to left gonias by drawing the line digitally from one gonial angle to other gonial angle. The bigonial width were measured using a method described by Al-Shamout et al. (2012)<sup>4</sup>

## **Gonial angles**

For measuring the gonial angle, Two lines were sketched on the panoramic radiographs digitally. (Mattila *et al.*)<sup>5</sup> A tangential line extending from the most inferior points at the gonial angle to the lower border of the body of mandible and the another line tangential to the posterior borders of the ramus and the condyle. The gonial angle formed by the intersection of these two lines, measured on the both sides.<sup>4,5,6</sup>

### Statistical analysis

The collected data from the subjects were entered in MICROSOFT EXCEL 2020 and then transferred into SPSS version 25 (SPSS Inc., IL, USA). Independent *t*-test was carried out to compare in values of bigonial width, right gonial angle & left gonial angle between the gender. Paired *t*-test was used to compare between right and left gonial angle. One-Way ANOVA was used to compare the difference in the studied parameters according to different age groups. Turkey's *post hoc* test was not applied as there was no statistically significant difference observed by ANOVA. Discriminant function analysis was used to determine the variables showing discrimination between naturally occurring groups and to determine which variables were the best predictors.

### Results

The mean age of males was found to be 45.22±16.22, while mean age of females was 40.37±12.73. Mean bigonial width was 23.70±1.44 in males and that in females was 22.53±1.21. Right and left gonial angle in males is 115.55±6.98 and 115.48±7.19 respectively and that in females was 121.58±4.98 and 121.55±6.00 respectively. The overall mean age was 42.79±14.74 years. Overall mean bigonial width was 23.11±1.45. Overall Right and left gonial angle is 118.57±6.76 and 118.52±7.27 respectively. [Table 1] The sample was divided into seven groups Group A: 11–20 years, Group B: 21–30 years, Group C: 31–40 years, Group D: 41–50 years, Group E: 51–60 years, Group F: 61–70 years and Group G: 71–80 years. Mean values are shown in [Table 2] One-way ANOVA was used to compare the difference in the studied parameters according to different age groups. Turkey's *post hoc* test was not applied as there was no statistically significant difference observed by ANOVA Paired *t*-test was used to compare between right & left gonial angle. There was no significant difference between right & left gonial angle as *p*-value is greater than 0.05.

The subjects were then divided based on gender into males and females and compared using the Independent *t*-test to check any overall gender difference. Gender difference in gonial angle and bigonial width were statistically significant with  $p \leq 0.05$ . A discriminant analysis was conducted to predict gender. Significant mean differences between males and females were found for all measurements. Discriminant analysis revealed that the strongest predictor for gender was Right gonial angle, followed by Left gonial angle and Bigonial width.

The discriminate function equation is as follows:

$$D = - 5.976 - 0.355 (\text{Bigonial width}) + 0.080 (\text{Right gonial angle}) + 0.040 (\text{Left gonial angle})$$

[Bigonial width in centimetres and gonial angle in degree] The discriminate functions at group centroids (group means) were -0.569 for males and 0.569 for females. In the present study, sectioning point was found to be 0. For any unknown sample, for prediction of sex, we calculate the value obtained from the above-mentioned equations using the three variables. If the value is lower than this sectioning point, i.e. -0.2, sample is male, and if the value is greater than this point that indicates a female. Above classification results revealed that 65 % of the males and 79 % of the females were correctly classified according to the prediction equation and the overall correct classification was 71.5

%. Bigonial width alone discriminated gender 68 % accurately, right gonial angle 71% and left gonial angle 67%. [Table 3]

## Discussion

Forensic odontology is the study of dental applications in legal investigations. Forensic odontology plays a significant role in identification in any sort of mass disaster events that result in several fatalities that may not be identified by means of conventional methods. One of the essential aspects of forensic odontology is to predict gender using fragmented jaws as intact skull is not available for analysis in mass disasters.

Mandible, being the largest, strongest and movable bone of the skull, is frequently found intact for forensic examination. The impact of the muscular attachments on the size and shape of the mandible is observed from the time of development of the mandible.

Numerous studies have reported that panoramic radiographs are reproducible and accurate for both linear and angular measurements of mandible. **Larheim and Svanaes (1986)** <sup>6</sup> have found that the gonial angles assessed on a panoramic radiograph was almost identical that measured on a dried mandible. The present study aimed for aimed to explore the impact of both age and gender on gonial angle and bigonial width in the dentulous Gujarat population using digital orthopantomographs.

A retrospective study was conducted at karnavati school of dentistry. Digital panoramic radiographs randomly collected from Digora software (version 2.7). Around 200 participants from age group 11 to 80 years with 100 males & 100 females. The sample was divided into seven groups Group A: 11–20 years, Group B 21–30 years, Group C 31–40 years, Group D 41–50 years, Group E 51–60 years, Group F 61–70 years and Group G 71–80 years. Only, Panoramic radiographs of dentulous & partially edentulous, adult patient age range from 11 to 80 years, High quality radiograph with no error included in present study. Panoramic radiograph with positioning error, Completely edentulous & child patients, any pathology, fracture, developmental disturbances were excluded in this study.

Investigations were carried out to determine if there was a variation in three mandibular parameters, bigonial width, right and left gonial angles in orthopantomographs with increasing age and both genders. In the present study, there was no statistically significant change with regard to bigonial width across the age groups. This was in accordance with Shaw *et al.* (2011) <sup>7</sup>, Ghaffari *et al.* (2013) <sup>8</sup> and in contrast with Al-shamout *et al.* (2012) <sup>4</sup>, Abbas *et al.* (2020) <sup>9</sup>, Velpula *et al.* (2018) <sup>10</sup>, Mostafa *et al.* (2020) <sup>11</sup> who found that the bigonial width increased with an increasing age and some authors Leversha *et al.* (2015) <sup>12</sup> found decreasing bigonial width with the age.

In the present study, although there was an increasing trend of gonial angle with age; it was not statistically significant. This was in agreement with Chole *et al.*

(2013)<sup>13</sup>, Dutra *et al.* (2004)<sup>14</sup>, Oksayan *et al.* (2012)<sup>15</sup> and Raustia and Salonen (1996)<sup>16</sup> who did not find any significant differences in the gonial angle with respect to age of their subjects. On the other hand, our results contradicted some researchers like Poongodi *et al.* (2015)<sup>17</sup>, Jambunath *et al.* (2016)<sup>18</sup>, Abbas *et al.* (2020)<sup>9</sup> who found that the gonial angle increased with age and other researchers Pecora *et al.* (2008)<sup>19</sup> where the gonial angle decreased with age. The difference between the results of these studies may be attributed to the different populations, age ranges and different dental status selected for the studies.

Our investigations revealed a statistically significant variation in mandibular morphology between both the genders, but not with age. It was found that males have longer bigonial width than females but a smaller gonial angle and vice versa. The results of the present study were in accordance with Vinay *et al.* (2013)<sup>20</sup>, Abbas *et al.* (2020)<sup>9</sup>, Datta *et al.* (2015)<sup>21</sup>, found the similar results and contrasting to the results obtained by Jambunath *et al.* (2016)<sup>18</sup> Females were found to have a significantly higher value of gonial angle than their male counterpart; which was similar to the results obtained by Ghosh *et al.* (2010)<sup>22</sup>, Joo *et al.* (2013)<sup>23</sup> and Leversha *et al.* (2015)<sup>12</sup>, Krishnan *et al.* (2019)<sup>24</sup>, Shah *et al.* (2020)<sup>25</sup>, Datta *et al.* (2015)<sup>2</sup>, However our results were not in agreement with Dutra *et al.* (2004)<sup>14</sup> & Radhakrishnan *et al.* (2017)<sup>26</sup>, Oksayan *et al.* (2012)<sup>27</sup>, Shadabi *et al.* (2009)<sup>28</sup>. Where no significant difference was found between genders. Pecora *et al.* (2008)<sup>29</sup> concluded that the women had a downward and backward rotation in mandible but men had a forward rotation in mandible. Hence, the increase in mandibular angle in females is more than in men.

The present study found no significant difference when comparing left and right gonial angles. This was in agreement with Leversha *et al.* (2015)<sup>12</sup>, Shadabi *et al.* (2009)<sup>28</sup>, Ozkan *et al.* (2019)<sup>30</sup>, Shrestha *et al.* (2020)<sup>31</sup>, On the contrary, some researchers Abbas *et al.* (2020)<sup>9</sup>, found that the gonial angle on the right side was significantly smaller than on the left possibly because of more use of the right side, whereas Al-Shamout *et al.* (2012)<sup>4</sup> and Huumonen *et al.* (2010)<sup>32</sup> found right gonial was larger than left side.

In the present study, discriminant analysis was employed, testing each combination of variables. Each of the variables showed statistically significant differences between gender. Discriminant analysis revealed that the strongest predictor for gender discriminant was Right gonial angle, followed by Left gonial angle and least was Bigonial width. Above classification results revealed that 64 % of the males and 79 % of the females were correctly classified according to the prediction equation and the overall correct classification was 71.5 %. Bigonial width alone discriminated gender 68 % accurately, right gonial angle 71% & left gonial angle 67%. Females were slightly more accurately identified than males.

Marinescu *et al.* (2013)<sup>33</sup> investigated 200 mandibles in Romanian population & achieved 84% accuracy in correctly sexing the mandibles with 3 measurements: chin height, bigonial width and bicondylar breadth and only one variable bigonial width has produced a sex determination accuracy of 80.5%. Jambunath *et al.* (2016)<sup>18</sup> evaluated accuracy of classification for sexual dimorphism & found to 66% in gonial method. Bento *et al.* (2021)<sup>34</sup> did similar study of 471 mandibles of

215 females and 256 males in Brazilian population & correctly classified 77.50% and 80.20% of the cases, respectively, with a total percentage of agreement of 78.70%. The bigonial width (77.60%) was the variable with the highest agreement rates among males and females, respectively. This varying result could be due to different sample size.

## **Conclusion**

There was no significant variation in measurement of Bigonial width across the age. There was no significant increase or decrease in measurement of Gonial angle across ages. On evaluating and comparing, males have higher value of bigonial width, compared to female counterparts. Comparing gonial angle, Females have significantly larger value of gonial angle than males. There was no significance difference between right & left gonial angle. Mean value was almost equal in both the sides. It was seen that 65 % of the males and 79 % of the females were correctly classified according to the prediction equation and the overall correct classification was 71.5 %. Bigonial width alone discriminated the gender 68 % accurately, right gonial angle 71% and left gonial angle 67%. Digital panoramic radiography is an important tool for examining different mandibular parameters to detect morphological changes related to age and gender. Gonial angle and Bigonial width are one of the most important and widely used landmarks in orthodontic tracking to assess growth pattern and treatment planning. Excluding some limitations, digital imaging can be used to assist in sex determination for forensic studies. Further research should be conducted across other areas and hospitals in Gujarat for more significant results.

**Financial support and sponsorship:** nil.

**Conflicts of interest:** there are no conflicts of interest.

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Table 1: Table showing mean & standard deviation of age, bigonial width, right gonial angle & left gonial angle in males & females.

<b>GENDER</b>	<b>AGE (mean± SD)</b>	<b>BIGONIAL WIDTH (mean± SD)</b>	<b>RIGHT GONIAL ANGLE (mean± SD)</b>	<b>LEFT GONIAL ANGLE (mean± SD)</b>	<b>P – value (Independent t- test)</b>
MALES	45.22±16.22	23.70±1.44	115.55±6.98	115.48±7.19	0.00
FEMALES	40.37±12.73	22.53±1.21	121.58±4.98	121.55±6.00	0.00
TOTAL	42.79±14.74	23.11±1.45	118.57±6.76	118.52±7.27	0.00

Table 2: Table showing mean & standard deviation of bigonial width, right gonial angle and left gonial angle in different age groups & gender.

<b>Bigonial width</b>			<b>Right Gonial angle</b>		<b>Left Gonial angle</b>	
Age Group	Male	Female	Male	Female	Male	Female
A (11–20)	23.45±1.25	21.86±0.69	118.14±7.86	124.22±4.39	119.27±9.92	120.56±5.6
B (21–30)	23.45±1.84	22.48±1.16	113.85±8.27	121.57±5.97	113.72±8	121.21±7.99
C (31–40)	22.89±1.53	23.53±1.02	115.7±6.6	122.6±4.04	115.86±7.56	122.66±4.96
D (41–50)	23.37±0.99	22.78±1.15	117.62±5.39	120.45±6.04	115.72±5.87	121.52±6.92
E (51–60)	24.8±1.25	22.71±1.66	115.54±7.13	120.20±4.49	115.49±5.98	119.96±5.12
F (61–70)	24.18±1.61	22.02±.96	113.4±6.27	121.82±3.51	114.82±7.11	122.27±3.22
G (71–80)	22.75±1.38	-	116.26±11.15	-	119.03±13.49	-
<b>ANOVA F Value</b>	1.141		2.092		1.371	
<b>p Value</b>	.340		.056		.228	

Table 3: Discriminant function analysis.

		<b>Accuracy of classification</b>	<b>Structure Matrix</b>	<b>Wilk's lambda</b>	<b>p-value</b>
Bigonial width		68	-0.770	0.837	0.00
Right angle	Gonial	71	0.873	0.800	0.00
Left angle	Gonial	67	0.805	0.825	0.00

Figure.1 Bigonial width measuring distance between two gonions.

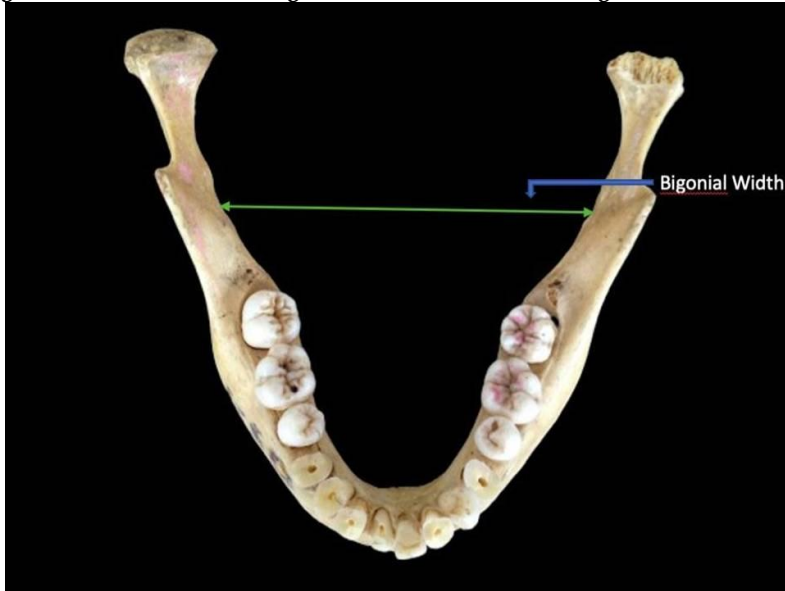
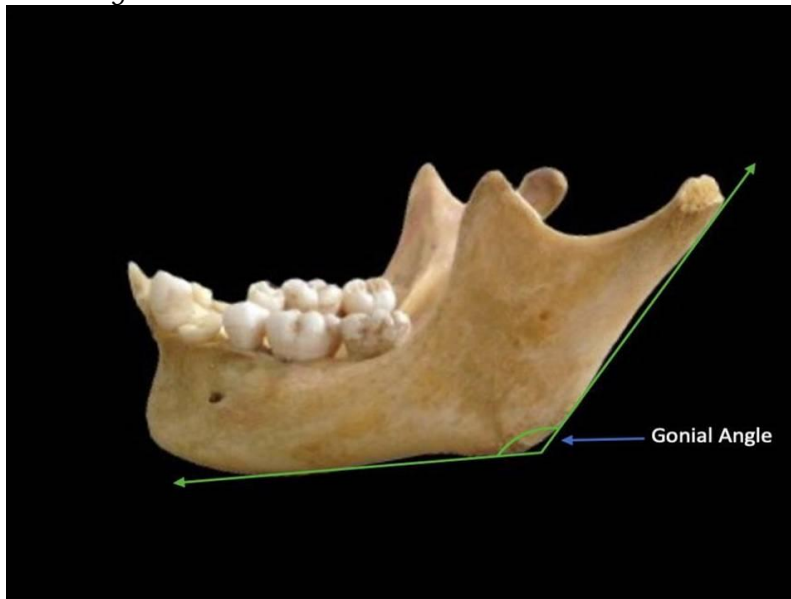
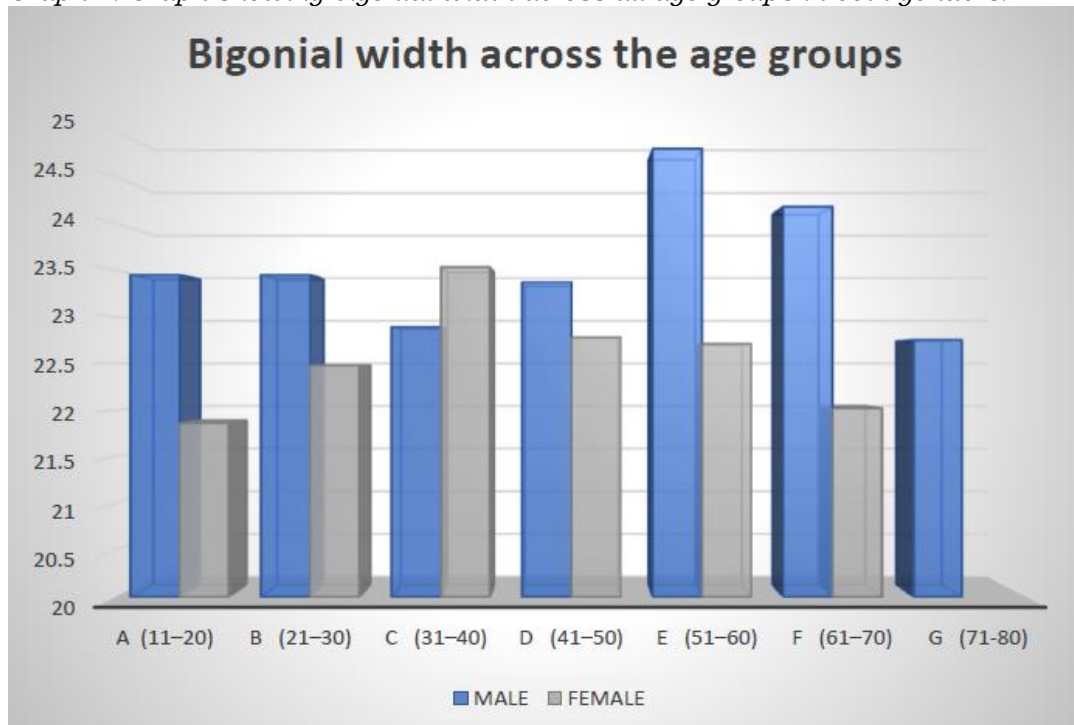


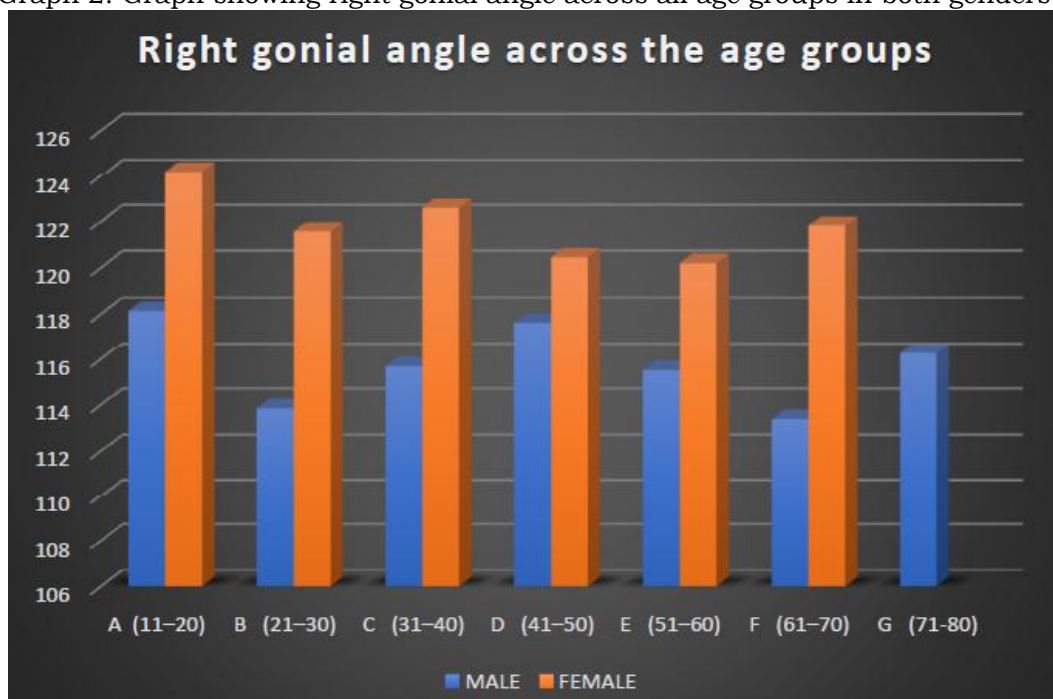
Figure 2. Gonial angle between mandibular line and ramus line.



Graph 1: Graph showing bigonial width across all age groups in both genders.



Graph 2: Graph showing right gonial angle across all age groups in both genders.



Graph 3: Graph showing left gonial angle across all age groups in both genders.

