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Gonial Angle Measurement: Panoramic Radiography or Lateral Cephalogram?

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Abstract

Objective: Measuring the gonial angle is an essential diagnostic tool for identifying craniofacial disorders. In this study, gonial angle measurements from panoramic radiographs and lateral cephalograms of individuals with skeletal class I malocclusion were compared. The study also attempts to determine which radiography method is best suited for precisely determining the gonial angle.

Methods: Lateral cephalograms and panoramic radiographs of 70 orthodontic patients (34 males, 36 females; mean age: 16.8 years) were selected from the department's archive. On the lateral cephalograms, SNA, SNB, ANB, GoGn-SN, and gonial angle measurements were made; on the panoramic radiographs, measurements of the right and left gonial angles were made. Gender differences were analyzed using Student *t*-tests, and Pearson's correlation analysis was used to assess the relationship of angles. The reliability of measurements was evaluated by calculating repeatability coefficients.

Results: The lateral cephalogram's mean gonial angle value was 126.4 ± 4.75, and in the panoramic radiography was 124.8 ± 5.39 on the right side, and 125.1 ± 5.67 on the left side. The differences between the gender in terms of GoGn-SN and gonial angle in lateral cephalogram were statistically significant ($P < .05$). The correlation between the gonial angle in lateral cephalogram and panoramic radiography was determined to be significant.

Conclusion: Panoramic radiographs can accurately assess the gonial angle, just like lateral cephalograms. The advantage of using panoramic radiographs is that they allow easy measurement of both side angles without the need for superimposition of anatomical landmarks.

Keywords: Cephalometry, gonial angle, orthodontics, panoramic radiography

INTRODUCTION

Accurate diagnosis and effective treatment planning in orthodontics rely heavily on the data obtained from various diagnostic aids, including clinical examinations, study models, and relevant radiographs. For orthodontic patients, the lateral cephalogram and panoramic radiography are important tools in developing treatment plans. The lateral cephalogram serves as a valuable tool in evaluating the skeletal correlation, growth trends, dental arrangement, and the alveolar process. It offers crucial information in these areas, allowing for a comprehensive assessment of the patient's oral and facial structures.[1] In fact, cephalometric analysis is considered the gold standard for achieving diagnostic objectives at the onset of orthodontic treatment. One specific application of lateral cephalometry in orthodontics is the measurement of parameters such as the gonial angle.[2]

Determining the gonial angle requires creating a tangent line tracing the posterior edge of the ramus and another tangent tracing the inferior edge of the mandible on the lateral cephalogram. This particular angle is essential in evaluating the vertical dimensions and symmetry of the facial skeleton.

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The gonial angle holds significant importance in the field of orthodontics as it serves various purposes. First, it aids in determining the growth pattern of an individual, allowing orthodontists to assess the rotation of the mandible.[3] Also, it has a critical role in determining the extraction approach for class II patients.[4] Moreover, the gonial angle assists in making informed decisions regarding the need for surgery in skeletal class III cases[5] and estimating age and gender in forensic medicine.[6,7] Furthermore, it is an important parameter for assessing facial skeletal symmetry. In the realm of maxillofacial surgery, the gonial angle can also be utilized to investigate the risk of mandibular angle fracture.[8] Traditionally, this angle is measured with lateral cephalometric radiographs. Despite this, it is important to consider that the validity of these measurements may be questionable due to the superimposition of the 2 side angles, as noted by Larheim and Svanaes.[9]

Panoramic radiography [orthopantomogram (OPG)] is widely recognized as the standard for dental diagnosis and treatment planning in the disciplines of dentistry and orthodontics. This imaging modality offers a plethora of valuable insights into the teeth and the adjacent bone structure. It proves to be highly advantageous in identifying a range of conditions including cysts, cancer, abnormalities in teeth shape, congenital absence or premature loss of teeth, teeth that are abnormally retained or fused to the jawbone, the path of tooth eruption, bone abnormalities, and mandibular asymmetry.[10,11] Accurate diagnosis of mandibular asymmetry before initiating treatment is crucial to effectively address the limitations and explore appropriate therapeutic options. While many practitioners do not typically rely on panoramic images for diagnosing mandibular asymmetry,[12,13] there is support from certain researchers. Mattila et al.[11] stated that panoramic radiography offers a more precise measurement of the gonial angle compared to lateral cephalography, as panoramic radiography allows for individual measurement of both sides' gonial angles without any superimposition.

In summary, panoramic radiography plays a vital role in dental and orthodontic practices, providing comprehensive information for diagnosis and treatment planning. While its use in diagnosing mandibular asymmetry may vary among practitioners, some researchers advocate for its effectiveness in accurately determining the gonial angle.

Several researchers have provided conflicting findings regarding the accuracy of OPGs. While some researchers claim that OPGs exhibit greater accuracy, others have documented no statistically significant variance between these 2 imaging methods.[1,14,15] In a study carried out by Araki et al., the measurement of gonial angles on dry skulls revealed slightly smaller values on OPGs compared to lateral cephalograms.[16]

The primary objective of this research was to assess the precision of orthopantomography (OPG) in quantifying the angles of the left and right gonial. To accomplish this, we compared the angles measured from OPG with those derived from lateral cephalograms of patients having class I malocclusion and permanent dentition. Since previous studies have reported inconsistent results, we aimed to provide a precise assessment of OPG's measurement capabilities. Additionally, the study aimed to identify the most suitable radiographic technique for accurately measuring the gonial angle.

MATERIAL AND METHODS

This retrospective study has received approval from the Ethics Committee of Ankara Yıldırım Beyazıt University (Approval No: 243-05, Date: May 16, 2023). The study's sample size was calculated using G*Power software (version 3.1.9.213) developed by the Institute of Experimental Psychology at Heinrich Heine University in Dusseldorf, Germany. With an α error of 0.01, a power of 80%, and an effect size of 0.25, a sample size of 70 patients is recommended for this study.

The research sample comprised 70 patients (36 females and 34 males) having class I skeletal relationship. The sample consisted of lateral cephalograms and OPGs. Informed consent was obtained from all of the patients in the Department of Orthodontics. The patients' ages varied between 15 and 23 years, with an average age of 16.83 years (Table 1). The digital lateral cephalograms and OPGs were obtained using the Planmeca Promax 2D (Planmeca OY Asentajankatu 6, Helsinki, Finland). The acquisition of radiographs was performed by the same technician, using the same device, and all patients were in natural head positions. Subsequently, all radiographs were carefully examined and assessed.

Table 1. Descriptive Statistics of the Variables

Variables	n	Mean	Standard Deviation	Minimum	Maximum
Age	70	16.83	1.849	15.00	23.00
SNA	70	80.7	2.68	74	86
SNB	70	78.3	2.81	71	84
ANB	70	2.4	1.22	1	4
GoGn/SN	70	31.9	5.26	21	46
Gonial angle cephalogram	70	126.4	4.75	115	138
Right gonial angle OPG	70	124.8	5.39	114	137
Left gonial angle OPG	70	125.1	5.67	109	138

The radiographs were selected based on specific inclusion criteria. These criteria included the requirement for the radiographs to possess high quality and sharpness. Additionally, all radiographs had to be captured using the same device. OPGs and lateral cephalograms should be taken on the same day for each patient. Only patients with skeletal class I malocclusion were included in the study. The exclusion criteria encompassed individuals with a documented history of trauma, prior facial or mandibular surgical procedures, syndromes that impact the face or jaw, and facial asymmetry.

SNA, SNB, ANB, GoGn-SN, and gonial angle measurements were analyzed on the lateral cephalograms, while right and left gonial angle measurements were analyzed on the panoramic radiographs (Table 1). Measurements were performed using ImageJ 1.48 software (US National Institutes of Health, Bethesda, Md, USA) by the same author.

In the OPG, the gonial angle was measured with 2 lines: one along the lower border of the mandible, and the other along the distal border of the ascending ramus and condyle on both sides (Figure 1).[1,11,27]

In lateral cephalograms, the Gonial angle was determined by identifying the intersection point of the tangential planes formed by the lower border of the mandible, the distal border of the ascending ramus, and the condyle (Figure 2).[1,11,27]

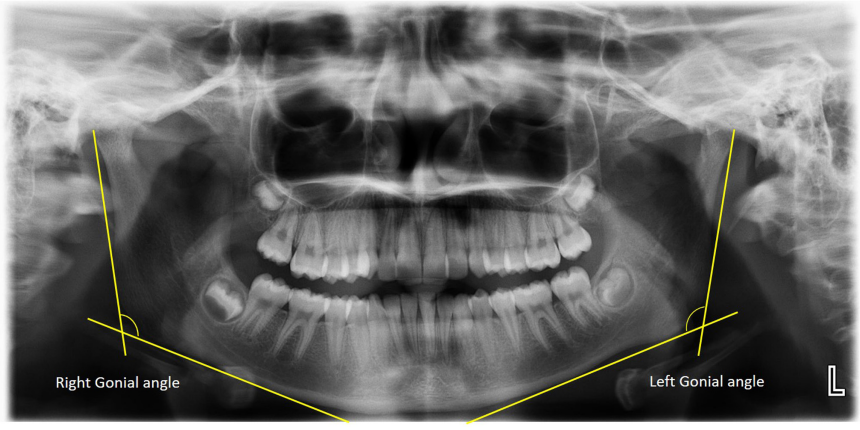

Figure 1. Right and left gonial angle measurement in orthopantomogram.

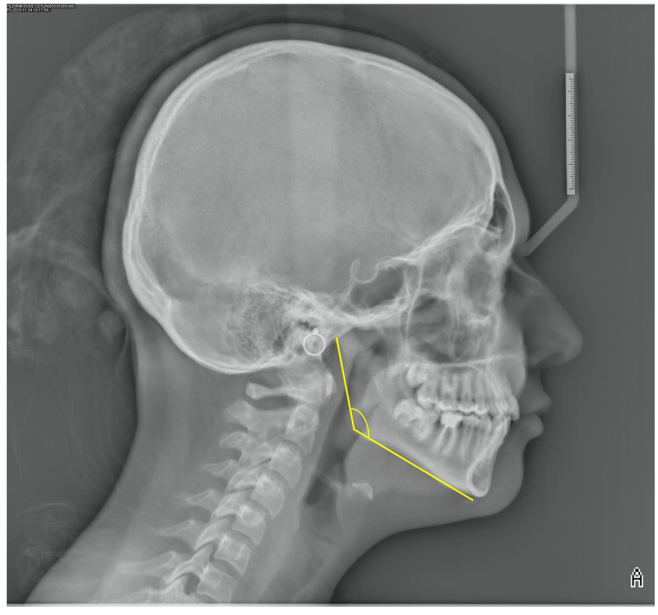

Figure 2. Gonial angle measurement in lateral cephalogram.

Table 2. Repeatability Coefficients of the Measurements

	Repeatability
Variables	R^2
SNA	0.9972
SNB	0.9975
ANB	1.0000
GoGn/N	1.0000
Gonial angle cephalogram	0.9988
Right gonial angle OPG	0.9994
Left gonial angle OPG	0.9973

Method Error

The repeatability of landmark identification and measurement sensitivity was assessed by the same author, who repeated the measurements on 20 randomly selected patients after a 20-day interval. The intra-observer reliability for all variables was found to be high, ranging between 0.997 and 1.00 (Table 2).

Statistical Analysis

The Statistical Package for Social Sciences, version 15.0 software (SPSS Inc.; Chicago, IL, USA) was utilized to conduct the statistical analysis. Student's *t*-tests were used to compare measurements by gender. Pearson's correlation analysis was utilized to assess the connections between the angles. Repeatability coefficients were calculated to evaluate measurement reliability. A significance level of $P < .05$ was established for statistical analysis.

RESULTS

The mean value of the SNA angle was 80.7° ± 2.68°, the mean value of the SNB angle was 78.3° ± 2.81°, the mean value of the ANB angle was 2.4° ± 1.22°, and the GoGn-SN angle was 31.9° ± 5.26° (Table 1).

The mean value of the gonial angle in the cephalogram (126.4° ± 4.75°) was found higher than the right gonial angle in OPG (124.8° ± 5.39°) and left gonial angle in OPG (125.1° ± 5.67°) (Table 2).

Based on the *t*-test results, it was found that there is a statistically significant difference between the gender averages when it comes to the "GoGn-SN angle" and "gonial angle cephalogram" variables ($P < .05$). However, for other variables, no statistically significant difference was observed between the gender averages (Table 3).

According to Pearson correlation analysis, there is a positive correlation between the gonial angle cephalogram and the right gonial angle OPG ($P < .01$) and between the gonial angle cephalogram and the left Gonial angle OPG ($P < .01$). There is also a positive correlation between the left gonial angle OPG and the right gonial angle OPG ($P < .01$) (Table 4).

DISCUSSION

This study aimed to compare gonial angle measurements in permanent dentition patients (mean age 16.83 years) using lateral cephalograms and panoramic radiography. The current investigation reveals a significant association between the gonial angle cephalogram and the right gonial angle OPG ($P < .01$), as well as between the gonial angle cephalogram and the left gonial angle OPG ($P < .01$) (Table 4).

Unlike the findings of Adil et al.,[17] the present study did not discover any significant disparity between panoramic radiographs and lateral cephalometric radiography when assessing the measurement of the gonial angle. This discrepancy is believed to stem from the variation in measurement techniques employed. While our study utilized digital measurements, Adil et al. relied on manual measurement methods.

In this study, in the panoramic radiography, the mean value of the gonial angle was 124.8, and in the lateral cephalogram, it was 126.4. The mean values of the gonial angle in the lateral cephalogram were higher than the gonial angle in the OPG.

Hammad ul-Haq et al.[18] found significant differences between the gonial angle size obtained through panoramic radiography and the measurements obtained through cephalometry using Tweed, Steiner, and Down methods. These variations

Table 3. Comparison of Measurements by Gender (Student's *t*-Test)

	t-Tests; Grouping: Gender								
	Gender								
	Male			Female					
Variables		Mean	Standard Deviation	n	Mean	Standard Deviation	*t*-Value	*df*	*P*
Age	34	17.04	2.074	36	16.64	1.615	0.883	68	.380
SNA	34	81.2	2.64	36	80.2	2.65	1.691	68	.096
SNB	34	78.8	2.56	36	77.9	2.99	1.443	68	.154
ANB	34	2.4	1.19	36	2.3	1.26	0.463	68	.645
GoGn/SN	34	30.3	5.23	36	33.3	4.93	–2.456	68	.017
Gonial angle cephalogram	34	125.1	5.19	36	127.6	3.98	–2.292	68	.025
Right Gonial angle OPG	34	124.0	5.71	36	125.6	5.04	–1.209	68	.231
Left gonial angle OPG	34	124.1	6.09	36	126.1	5.13	–1.548	68	.126

Table 4. Correlations of Cephalometric Variables

Correlations				
Variables	Pearson Correlation	Gonial Angle Cephalogram	Right Gonial Angle OPG	Left Gonial Angle OPG
Gonial angle cephalogram	*r*	1	0.907**	0.915**
	P		**.000**	**.000**
	n	70	70	70
Right gonial angle OPG	*r*	0.907**	1	0.928**
	P	**.000**		**.000**
	n	70	70	70
Left gonial angle OPG	*r*	0.915**	0.928**	1
	P	**.000**	**.000**	
	n	70	70	70

*Correlation is significant at the .05 level.
**Correlation is significant at the .01 level.

could potentially be explained by distortions present in panoramic images, as well as technical errors that might have occurred during the radiograph procedure, such as the failure to precisely observe the natural head position. Additionally, errors made by technicians could have also influenced the accuracy of the measurements.

According to Bhullar et al.'s study,[19] the average measurement of the gonial angle in lateral cephalograms was found to be 123.62°± 6.80°. On the other hand, the average measurement of the gonial angle in panoramic radiography (OPG) was slightly lower at 122.82° ± 7.54°. When specifically examining OPG images, the average measurement of the right gonial angle was 123.12° ± 6.7°, while the average measurement of the left gonial angle was 122.53° ± 11.0°. In terms of gender differences, females had a slightly higher average gonial angle of 123.94° in lateral cephalograms, whereas males had an average measurement of 123.23°. In panoramic radiography, females had an average Gonial angle of 122.69°, while males had an average measurement of 122.98°.

In this study, all patients had a skeletal class I with a mean SNA angle of 80.7° ± 2.68°, SNB angle of 78.3° ± 2.81°, ANB angle of 2.4° ± 1.22°, and normodivergent with a mean GoGn-SN angle of 31.9° ± 5.26°. In a study conducted by Shahabi et al.,[15] the external gonial angle was examined using both lateral cephalograms and panoramic radiographs in class I patients, which is similar to the current study. The researchers concluded that panoramic radiography can effectively determine the gonial angle with the same level of accuracy as a lateral cephalogram. Our research findings align with the conclusions drawn by Shahabi et al.[15]

Alhaija conducted an assessment of the feasibility of panoramic radiographs in determining the inclination and steepness of the mandible. The study revealed a strong association between the measurements obtained from both radiographs. As a result, they deduced that panoramic radiography serves as a valuable instrument for quantifying the gonial angle, which serves as an indicator for mandibular steepness and, consequently, the direction of mandibular growth.[20]

Fatahi and Babouei conducted a study to assess the dependability of cephalometric measurements derived from OPGs. By comparing measurements obtained from dry skulls with those obtained from panoramic radiographs, they found that the gonial angle exhibited the strongest correlation between panoramic and cephalometric radiographs, while the length of the mandibular body showed the weakest correlation. Furthermore, when considering various growth patterns, it was observed that the gonial angle and ramus height displayed the highest correlation between the 2 types of radiographs.[21] Alhaija[22] and Fatahi and Babouei[21] reached the conclusion that the utilization of the OPG to ascertain the growth direction could prove beneficial. This is primarily due to the fact that a significant number of dentists commonly request an OPG for their patients during regular dental check-ups. In the study conducted by Oksayan et al.,[22] the researchers examined the gonial angle in panoramic and lateral cephalometric radiographs across 3 different skeletal groups. The findings of the study revealed that there were no notable variations observed among the skeletal classes in terms of the gonial angle.

In their study, Kurt et al.[23] employed OPGs to assess mandibular asymmetry in patients with class II subdivision malocclusion. They measured condylar, ramal, and condylar–ramal asymmetry index values, as well as gonial angle measurements. The researchers concluded that panoramic radiographs yield satisfactory outcomes. Additionally, panoramic radiographs offer several advantages, including their noninvasive nature, cost-effectiveness, and minimal radiation exposure to subjects. By utilizing panoramic radiography, healthcare providers can effectively minimize expenses and avoid subjecting patients to unnecessary radiation.

According to the findings of Jena et al.,[24] it was determined that OPGs have the potential to be utilized for assessing vertical and angular measurements, as well as for evaluating mandibular asymmetry from a side-to-side perspective. Ongkosuwito et al.[25] reached the conclusion that an OPG is equally dependable as a lateral cephalogram when it comes to assessing linear measurements of the mandible, specifically condylion-gonion, gonion-mention, and condylion-mention.

Radhakrishnan et al. conducted a study to compare the measurement of gonial angles between lateral cephalograms and panoramic radiographs. The researchers discovered that there existed no notable disparity in the outcomes obtained from employing either of the 2 methodologies. The study suggests that panoramic radiography can be considered a reliable method for measuring the gonial angle, particularly in cases where both sides' outlines are not visible on a lateral

cephalogram and in patients with asymmetry. Panoramic radiographs provide an accurate visualization of both the right and left gonial angles without any interference from superimposed images. These findings are consistent with the results of our study and are supported by Larheim and Svanaes,[9] as well as Akcam et al.[26]

The influence of the measurement technique on the size of the gonial angle has been highlighted by Mattila et al.[11] and Dahan et al.[27] There are 2 methods for determining the gonial angle: measuring the horizontal side formed by the tangent to the lower border of the mandible or measuring a line passing through the gnathion. To ensure accurate measurements, this study employed a line that tangentially intersects the lower border of the mandible to establish the horizontal plane of the gonial angle in both radiographs.

In the current investigation, the impact of gender on the size of the gonial angle was examined. The findings revealed that women exhibited a higher mean gonial angle size, as measured in lateral cephalogram, compared to men. Furthermore, a statistically significant distinction between males and females was observed in this regard ($P < .05$) (Table 3). According to the research conducted by Raustia et al. and Zangouei et al., it was found that the size of the gonial angle is not significantly influenced by gender.[2,28] Similarly to the results of the present study, Gungor et al. observed a notable distinction in the size of the left gonial angle when comparing men and women.[29] In Farahbod et al.'s study, it was observed that the average size of the gonial angle in women was marginally greater compared to men.[30] The findings of Shahabi et al.'s study are consistent with the results of the present study for both males and females.[15]

However, it is worth noting that despite this, the measurements of the gonial angle are commonly conducted using cephalograms rather than OPGs. The findings of the current investigation indicate that OPG can be utilized to perform these measurements just as frequently as lateral cephalograms, particularly in situations where the contours of both sides are not discernible and in cases of asymmetry before the acquisition of posteroanterior cephalograms.

CONCLUSION

The precise evaluation of the gonial angle greatly relies on the utilization of panoramic radiography, especially when the contours of both sides are not visible and in cases of facial asymmetry prior to obtaining Posteroanterior cephalograms. The assessment of the right and left gonial angles in panoramic radiography can be conveniently conducted without any superimposition of anatomical landmarks.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Ankara Yıldırım Beyazıt University (Approval No: 243-05, Date: May 16, 2023).

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author has no conflict of interest to declare.

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