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*Original article*

# Accuracy of Gonial Angle Measurement: Panoramic Radiography *versus* Lateral Cephalometry in Adult Class I Malocclusion

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***Abstract***
*Panoramic radiographs are more routinely taken than cephalometric radiographs in orthodontics. One of the values that can be evaluated in panoramic radiographs is the gonial angle. This study aims to investigate the accuracy of panoramic radiographs in evaluating the gonial angles obtained from lateral cephalometric radiographs and compare the results between pre and post-treatment, moreover, on both sides, right and left of the mandible in adult patients diagnosed with Class I malocclusion, and to find a possible correlation of gonial angle measurements between the panorama and lateral cephalometric radiographs. Gonial angles were assessed in 40 adult patients with Class I malocclusion (20 males and 20 females; average age: 23-26 years), obtained from orthodontic clinical records using both panoramic radiographs and lateral cephalograms. On lateral cephalograms, the gonial angle was determined at the intersection of the mandibular and ramus planes. On panoramic radiographs, the angle was measured by drawing one line along the inferior border of the mandible and another line along the posterior border of the ascending ramus on both the right and left sides. The measurements from the two radiographic techniques were statistically analyzed and compared using Pearson's correlation coefficient and a paired t-test. No statistically significant difference was observed between the gonial angles measured on panoramic radiographs and those obtained from lateral cephalograms. Additionally, the comparison between the right and left gonial angles measured on panoramic radiographs revealed no significant difference in mean values. In contrast, measurements from lateral cephalograms demonstrated a statistically significant decrease from 127.73° ± 6.69° pre-treatment to 126.95° ± 6.99° post-treatment, representing a mean reduction of 0.775° (p = 0.014). The ICC analysis demonstrated excellent agreement, with values ranging from 0.978 to 0.992 pre-treatment and 0.987 to 0.996 post-treatment. As there was no statistically significant difference between the gonial angle measurements obtained from panoramic radiographs and those from lateral cephalograms, panoramic imaging can be reliably used in orthodontics to assess the gonial angle, offering the advantage of minimal interference from overlapping anatomical structures. Our results revealed that the gonial angle changes after orthodontic treatment remained relatively stable for a period of (10 to 12) months after orthodontic treatment.*
***Keywords.*** *Lateral Cephalometric Radiographs, Panoramic Radiograph, Gonial Angle Measurements*

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## Introduction

Successful orthodontic diagnosis and treatment planning are based on data collected from diagnostic resources such as clinical assessments, radiographic images, and dental casts. Lateral cephalograms and panoramic radiographs are essential imaging techniques frequently utilized in an orthodontic clinic for evaluations. A lateral cephalogram provides critical information about growth patterns, skeletal structure, tooth position, and alveolar bone configuration. These assessments involve the use of defined anatomical landmarks on the skull for accurate measurements and analysis. In orthodontics, the gonial angle is commonly used to determine the rotation of the mandible. The gonial angle is a significant indicator for diagnosing the growth pattern of patients.

Downward and backward rotation is called a high angle in patients who showed an increase in the gonial angle. Contrary to this, the upward and forward direction of the mandible is called a low angle, and patients with this direction appear to have a decreased gonial angle. Therefore, the gonial angle is a key anatomical measurement used to evaluate an individual's mandibular growth pattern, assess mandibular rotation [1], and determine extraction strategies in Class II malocclusion cases [2]. It also plays a role in surgical decision-making for patients with Class III skeletal discrepancies [3] and serves as a useful indicator for age estimation in forensic investigations [4]. Additionally, the gonial angle helps in assessing facial skeletal symmetry. Traditionally, this angle has been measured using lateral cephalometric radiographs. However, as noted by Larheim and Svanaes [5], the precision of gonial angle measurements from lateral cephalograms may be compromised due to the superimposition of the right and left sides of the mandible.

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This overlap can hinder accurate evaluation, particularly when planning orthognathic surgeries. Panoramic radiography is widely regarded as a standard diagnostic tool in dental practice and is commonly utilized by both general dentists and orthodontists. It offers comprehensive information about the dentition and surrounding bony structures and is routinely employed for detecting tumors, cysts, congenitally missing, supernumerary teeth, ankylosed or unerupted teeth, eruption pathways, bone abnormalities, and mandibular asymmetry [6,7].

Accurate and early identification of facial asymmetries is essential for properly addressing potential treatment challenges and selecting appropriate therapeutic strategies. However, despite its diagnostic potential, panoramic radiographs are not commonly used by most clinicians for the specific evaluation of mandibular asymmetry [8,9]. Some researchers advocate the use of panoramic radiographs to measure the gonial angle. Mattila et al [7] reported that panoramic imaging may offer greater accuracy than lateral cephalography, as it allows for separate evaluation of the right and left gonial angles without the complication of image superimposition. Because panoramic radiographs capture both sides of the mandible, it is important to assess whether each side is visualized with equal clarity and reliability. Therefore, the objective of this study was to assess the validity of panoramic radiography in measuring the right and left gonial angles by comparing the results with those obtained from lateral cephalograms, before and after orthodontic treatment in adult patients with Class I malocclusion. The inclusion criteria were as follows:

1- All the selected patients had skeletal class I malocclusion.
2- No history of trauma
3- No previous facial/mandibular surgery.
4- No syndromes affecting the face or jaw.
5- No facial asymmetry.

## Materials and Methods

This observational retrospective study was carried out using panoramic and lateral cephalometric radiograph records of 40 subjects (20 females and 20 males; mean age, 23±3 years) diagnosed with skeletal and dental Class I malocclusion selected from a group of orthodontically treated patients. We assessed gonial angles using panoramic and lateral cephalometric radiographs. These images were acquired with a digital X-ray unit; the radiographs had to be of high quality and sharpness, all radiographs had to be taken using the same apparatus, and all patients were in a natural head position. Cephalometric landmarks were located, identified, and marked on the selected radiograph.

By using a 2H pencil on panoramic radiographs, the gonial angle was measured by drawing a line tangent to the lower border of the mandible and another line tangent to the distal border of the ascending ramus on both sides (Fig. 1A, B). In the lateral cephalograms, the gonial angle was measured at the point of intersection of the plane tangential to the lower border of the mandible and that tangential to the distal border of the ascending ramus (Fig. 2: A, B). The gonial angle at the intersection of these planes was traced on tracing paper and measured using a protractor. To confirm that all the considered patients had class I malocclusion, the sella-nasion-A point, sella-nasion-B point, and A point-nasion-B point angles were measured. Lateral cephalometric radiographs and panoramic records were collected at T0, before the start of treatment. T1: Post-treatment (when the treatment was completed), from (10 to 12) months

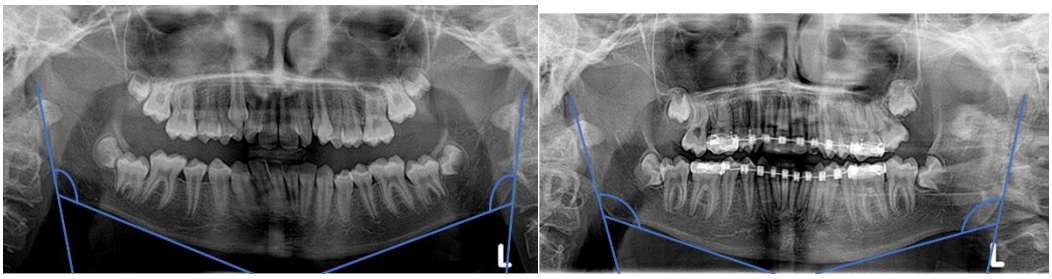

***Figure 1. The gonial angle in panorama (T0, T1)***

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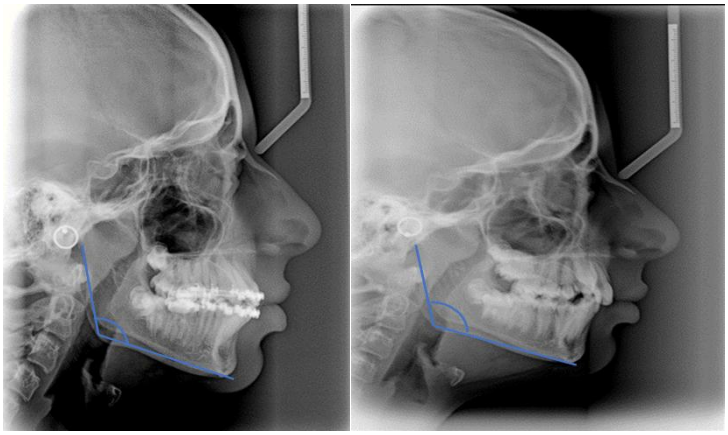

***Figure 2. The gonial angle in a lateral cephalogram (T0, T1)***

***Reliability of angular measurement error***

To assess the Reliability of measurements, 24 randomly selected OPGs and lateral cephalometric radiographs were re-evaluated by the same investigator after a 2-the disagreement was found to be not more than 0.5°. The intraclass correlation coefficient was >0.90, indicating that the magnitude of the difference between the two measurements was not clinically significant, and excellent reliability between both measurements was found.

## Results

***Statistical Analysis***

Data were presented as mean ± standard deviation. Comparisons between lateral cephalogram and panoramic radiograph measurements, as well as pre- and post-treatment changes, were analyzed using paired t-tests. Right and left panoramic measurements were also compared with the Paired T test. Agreement between the two imaging methods was assessed using Pearson correlation and intraclass correlation coefficient (ICC). Statistical significance was set at $p < 0.05$. Forty patients diagnosed with Class I malocclusion were included in this study.

***Comparison between the lateral cephalogram and the panoramic radiograph***

(Table 1) presents a comparison of gonial angle measurements obtained from lateral cephalograms and panoramic radiographs, both pre- and post-treatment. In the pre-treatment assessment, the mean gonial angle on lateral cephalograms was 127.73° ± 6.69°. This measurement did not differ significantly from those on panoramic radiographs, which were 127.25° ± 6.49° on the right side and 127.40° ± 6.38° on the left ($p = 0.068$ and $p = 0.200$, respectively). Following treatment, the mean angle on lateral cephalograms was 126.95° ± 6.99°. Similarly, no statistically significant differences were observed when compared to panoramic radiograph values of 127.03° ± 6.97° (right side) and 127.28° ± 7.18° (left side), with p-values of 0.727 and 0.051, respectively.

***Table 1. Comparison of gonial angles between lateral cephalogram and panoramic radiographs (Pre and Post treatment)***

| Comparison | Pre-Treatment TO Mean ± SD | p-value | Post-Treatment T1 Mean ± SD | p-value |
|---|---|---|---|---|
| Lateral Ceph vs Panorama Right | 127.73 ± 6.69 vs 127.25 ± 6.49 | 0.068 | 126.95 ± 6.99 vs 127.03 ± 6.97 | 0.727 |
| Lateral Ceph vs Panorama Left | 127.73 ± 6.69 vs 127.40 ± 6.38 | 0.200 | 126.95 ± 6.99 vs 127.28 ± 7.18 | 0.051 |

*Paired T-test; p-value < 0.05 considered significant.*

***Pre- vs post-treatment changes within each imaging method***

(Table 2) presents the treatment-related changes in gonial angle measurements within each imaging modality. Measurements from lateral cephalograms demonstrated a statistically significant decrease from 127.73° ± 6.69° pre-treatment to 126.95° ± 6.99° post-treatment, representing a mean reduction of 0.775° ($p = 0.014$). In contrast, panoramic radiographs showed non-significant changes: on the right side, from 127.25° ± 6.49° to 127.03° ± 6.97° ($p = 0.431$), and on the left side, from 127.40° ± 6.38° to 127.28° ± 7.18° ($p = 0.691$) (Figure 3).

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***Table 2. Pre- vs post-treatment gonial angle changes within each imaging method***

| Measurement | Pre-Treatment T0 Mean ± SD | Post-Treatment T1 Mean ± SD | Mean Difference | p-value |
|---|---|---|---|---|
| Lateral Ceph | 127.73 ± 6.69 | 126.95 ± 6.99 | 0.775 | 0.014 |
| Pan Right | 127.25 ± 6.49 | 127.03 ± 6.97 | 0.225 | 0.431 |
| Pan Left | 127.40 ± 6.38 | 127.28 ± 7.18 | 0.125 | 0.691 |

*Paired T-test; p-value < 0.05 considered significant.*

***Right vs left measurements on panoramic radiographs***

(Table 3) presents a comparison of right and left gonial angle measurements from panoramic radiographs. During the pre-treatment assessment, the mean angles were 127.25° ± 6.49° on the right and 127.40° ± 6.38° on the left, yielding a non-significant mean difference of -0.150° (p = 0.244). Similarly, post-treatment measurements showed values of 127.03° ± 6.97° on the right and 127.28° ± 7.18° on the left, corresponding to a non-significant mean difference of -0.250° (p = 0.105).

***Table 3. Right vs left panoramic gonial angle measurements***

| Phase | Right Mean ± SD | Left Mean ± SD | Mean Difference | p-value |
|---|---|---|---|---|
| Pre-Treatment T0 | 127.25 ± 6.49 | 127.40 ± 6.38 | -0.150 | 0.244 |
| Post-Treatment T1 | 127.03 ± 6.97 | 127.28 ± 7.18 | -0.250 | 0.105 |

*Paired T-test; p-value < 0.05 considered significant*

***Agreement and reliability between the lateral cephalogram and panoramic radiographs***

(Table 4) presents strong Pearson correlations between gonial angles measured on lateral cephalograms and panoramic radiographs. Pre-treatment correlations were r = 0.971 for the right side and r = 0.972 for the left side (p < 0.01 for both). Post-treatment correlations showed a slight increase to r = 0.981 (right) and r = 0.990 (left) (p < 0.01 for both). Furthermore, right and left panoramic measurements were also highly correlated, with coefficients of r = 0.991 (pre-treatment) and r = 0.992 (post-treatment) (p < 0.01 for both). The reliability between lateral cephalogram and panoramic measurements was evaluated using the intraclass correlation coefficient (ICC) (Table 4). The ICC analysis demonstrated excellent agreement, with values ranging from 0.978 to 0.992 pre-treatment and from 0.987 to 0.996 post-treatment (Figure 4).

***Table 4. ICC and Pearson correlations between lateral cephalogram and panoramic gonial angles***

| Phase | Comparison | Pearson Correlation (r) | p-value | ICC | 95% CI |
|---|---|---|---|---|---|
| Pre-Treatment T0 | Lateral Cephalogram vs Pan Right | 0.971** | 0.001 | 0.978 | 0.963–0.987 |
| | Lateral Cephalogram vs Pan Left | 0.972** | 0.001 | 0.992 | 0.987–0.996 |
| Post-Treatment T1 | Lateral Cephalogram vs Pan Right | 0.981** | 0.001 | 0.987 | 0.979–0.993 |
| | Lateral Cephalogram vs Pan Left | 0.990** | 0.001 | 0.996 | 0.993–0.998 |
| Pre-Treatment T0 | Pan Right vs Pan Left | 0.992** | 0.001 | – | – |
| Post-Treatment T1 | Pan Right vs Pan Left | 0.991** | <0.001 | – | – |

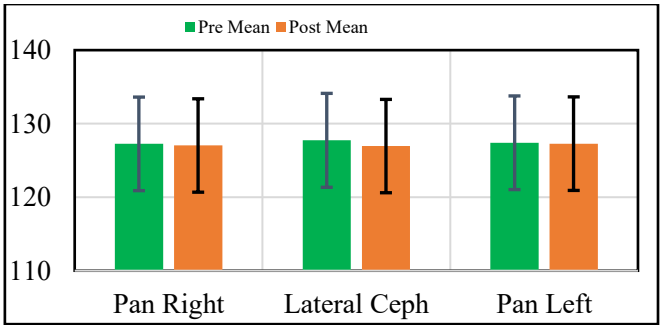


***Figure 3. Pre- vs post-treatment gonial angle changes within each imaging method***

***Correlation significant at p < 0.01*

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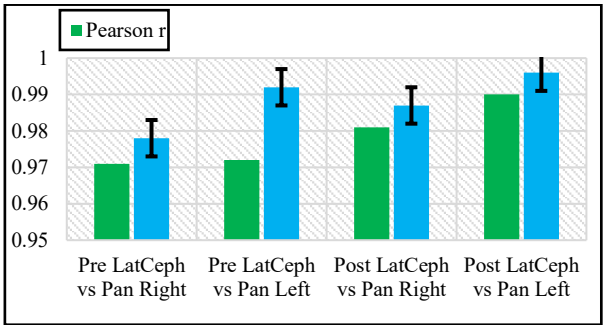


***Figure 4. Comparison of lateral cephalogram and panoramic measurements showing ICC and Pearson r with 95% CI***

## Discussion

An increased gonial angle indicates downward and backward rotation of the mandible (high angle), whereas a decreased gonial angle indicates upward and forward direction of the mandible (low angle). Therefore, accurate measurement of the gonial angle is crucial for proper treatment planning, especially for orthodontics and craniofacial surgical cases [2]. Many orthodontists believed that only the lateral cephalogram is useful to define the gonial angle [10]. On the other hand, several studies [11-15] have suggested that panoramic radiographs are valid for determining the gonial angle, and no statistically significant difference was observed between the gonial angles measured using lateral cephalograms and panoramic radiographs. These studies support our results, which found that in the pre-treatment assessment, the mean gonial angle on lateral cephalograms was 127.73° ± 6.69°. This measurement did not differ significantly from those on panoramic radiographs, which were 127.25° ± 6.49° on the right side and 127.40° ± 6.38° on the left ($p = 0.068$ and $p = 0.200$, respectively. Similarly, no statistically significant differences were observed when compared to panoramic radiograph values to the lateral cephalogram in post treatment.

In Class I patients, Shahabi et al [16]. supported our findings and declared that panoramic radiography may be a better choice than the lateral cephalogram for determining the gonial angle. Our results did not show significant differences between the two radiographic methods. But in contrast to these previous studies conducted by M. Bhullarin 2014, et al [17] showed a significant difference between gonial angle values measured from panoramic radiographs and those determined from lateral cephalometric images. The difference could be due to the selection of different malocclusion types, which were not specified. A study by Nada E Tashkandi et al.[18] Conducted a comprehensive panoramic and cephalometric assessment of gonial angle measurements among the different mandibular divergence groups using an online AI-driven assessment tool. The findings indicated significant differences between the two imaging modalities in measuring the gonial angle and variations in the gonial angles across different mandibular divergence patterns. The difference could be due to the use of different anatomical landmarks and points to perform the analysis. Moreover, it could be due to the small sample size that we used. The strength of our study would have been increased if conducted on a larger sample size.

In this study, the panoramic radiographs used provide an accurate visualization of both the right and left gonial angles without any interference from superimposed images. We assessed right vs left measurements on panoramic radiographs during pre-treatment and post-treatment, yielding a non-significant mean difference of -0.150° ($p = 0.244$). Similarly, post-treatment showed a mean difference of -0.250° ($p = 0.105$). These findings coincided with and agreed with the results of a previous study [9] and were supported by Larheim and Svanaes, as well as Akcam et al. [5,19]. Alhaija et al [20] evaluated the potential of panoramic radiographs to measure mandibular inclination and steepness; they observed a high correlation between the measurements taken using both types of radiographs. Thus, according to their study, panoramic radiographs are a useful tool for the measurement of the gonial angle, which is an indicator of mandibular steepness and, subsequently, the mandibular growth direction; this is in agreement with our study, where the reliability between lateral cephalogram and panoramic measurements was evaluated using the intraclass correlation coefficient (ICC) (Table 4).

The ICC analysis demonstrated excellent agreement, with values ranging from 0.978 to 0.992 pre-treatment and from 0.987 to 0.996 post-treatment (Figure 4). The high correlation between the gonial angle measured from lateral cephalometric and panoramic radiographs agrees with previous similar studies undertaken many population and with deferent gender and malocclusion(12,20-23) The significance of these findings is that panoramic radiographs are frequently requested by dentists and their availability makes it possible to assess the mandibular growth direction from the same radiograph, thereby avoiding the exposure of patients

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to extra radiation as well as providing a cost saving. Ohm and Silness [24] stated that gender had little effect on the size of the gonial angle. Therefore, it is suggested that the effect of age and gender on the gonial angle was so limited or absent [25]. In our study, the sample was equal between males and females, which denoted that gender did not affect measurements

## Conclusion

Panoramic radiographs are as effective as lateral cephalometric radiographs in evaluating mandibular steepness and inclination among orthodontic patients. Additionally, panoramic radiographs offer the benefit of less radiation exposure to subjects by reducing the need for multiple imaging procedures during diagnosis.

***Conflict of interest***. Nil

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