Reliability of Orthopantomogram in Determination of Gonial Angle

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ABSTRACT

Background: The gonial angle is a key cephalometric parameter used to assess vertical facial growth patterns. Although lateral cephalograms are the gold standard for its measurement, orthopantomograms (OPGs) are increasingly being used as an alternative diagnostic tool due to their accessibility and lower radiation exposure.

Objective: This study aimed to evaluate the reliability of gonial angle measurements obtained from OPGs by comparing them with those derived from lateral cephalograms.

Methods: A cross-sectional study was conducted on 200 patients (70 males, 130 females; mean age: 19.93 ± 6.643 years) at Bolan Medical College/Hospital, Quetta. Pretreatment lateral cephalograms and OPGs were obtained using a Kodak 9000 C machine. The gonial angle was measured by manual tracing of a tangent along the lower border of the mandible and another along the posterior ramus. Measurements were performed independently by two operators. Statistical analyses, including Pearson correlation, ANOVA, and paired t-tests, were performed using SPSS version 25.

Results: The mean gonial angle measured on OPGs was 124.62° ± 7.54° (right side) and 124.31° ± 8.37° (left side), compared to 124.65° ± 7.99° on lateral cephalograms. Strong correlations were observed between OPG and cephalometric measurements ($r = 0.894–0.898$, $p < 0.01$). ANOVA indicated no significant differences between the methods ($p > 0.05$).

Conclusion: OPGs demonstrated high reliability for gonial angle measurement, making them a viable alternative to lateral cephalograms for assessing vertical facial patterns in orthodontics. management.

INTRODUCTION

The accurate diagnosis of dental and skeletal discrepancies is a cornerstone of orthodontic practice, necessitating a combination of clinical assessments, patient history, and the analysis of diagnostic records, including radiographs and dental casts. Among the commonly employed radiographic tools, orthopantomograms (OPGs) and lateral cephalograms have long been utilized for evaluating craniofacial structures and developing tailored treatment plans. The advent of panoramic radiography marked a significant advancement in diagnostic imaging by providing a comprehensive view of dental and skeletal structures in a single image, offering critical insights into axial inclinations, developmental stages of teeth, and related anatomical features, such as the temporomandibular joint (3-6). In orthodontics, the evaluation of mandibular structures, particularly the gonial angle, serves as an important parameter for assessing vertical growth patterns and facial symmetry, which are critical for diagnosing and managing malocclusions and other craniofacial anomalies.

The gonial angle, defined as the intersection of the lower border of the mandible with the posterior ramus, is a cephalometric measure that provides valuable information about the vertical skeletal pattern of the face. Research on mandibular rotations, initially conducted by Bjork and colleagues, demonstrated that variations in mandibular growth contribute significantly to the development of different facial morphologies, including normal, short, and long facial types (8). Lateral cephalograms have traditionally been used to measure the gonial angle; however, the superimposition of bilateral mandibular structures on these images can lead to challenges in obtaining precise and reliable measurements (12). Conversely, OPGs allow for a clear and separate visualization of the right and left sides of the mandible, offering a distinct advantage in accurately assessing the gonial angle (14, 16). Despite their wide use, the reliability of OPGs for measuring vertical facial parameters has been a topic of debate. While some studies have validated the accuracy of OPG-derived angular measurements, others have questioned their ability to provide supplementary data comparable to that of lateral cephalograms (6, 9, 11, 13, 14, 14).

The diagnostic importance of the gonial angle in orthodontic practice stems from its role as an indicator of vertical facial growth and mandibular inclination. Accurate assessment of the gonial angle is critical for identifying facial growth patterns, planning orthodontic interventions, and predicting

treatment outcomes. Given the potential for OPGs to serve as a reliable alternative to lateral cephalograms, particularly in scenarios where the latter may not be feasible, this study aimed to evaluate the efficacy of OPGs in measuring the gonial angle and compare the results with those obtained from lateral cephalograms. By examining the correlation between these radiographic methods, this research seeks to clarify the diagnostic utility of OPGs in orthodontic assessments, address existing gaps in the literature, and contribute to the optimization of diagnostic strategies in clinical practice.

MATERIAL AND METHODS

This cross-sectional study was conducted in the Department of Orthodontics, Bolan Medical College/Hospital, Quetta, from October 22, 2021, to April 22, 2022. The study included a sample of 200 patients aged between 12 and 30 years who met the inclusion criteria. Participants were selected based on the presence of fully erupted permanent dentition and the availability of high-quality orthopantomograms (OPGs) and lateral cephalograms. Exclusion criteria included a history of mandibular trauma, previous orthodontic treatment, pathological jaw lesions, or poor-quality radiographs. Ethical approval for the study was obtained from the institutional review board, and the research adhered to the principles outlined in the Declaration of Helsinki. Informed consent was obtained from all participants, and parental consent was secured for those under the age of 18 years.

Radiographic data were collected using a Kodak 9000 C machine. Pretreatment lateral cephalograms were obtained with a film size of 11 × 14 inches, and panoramic radiographs were acquired using a 10 × 12-inch film. Both types of radiographs were evaluated to measure the gonial angle, which was defined as the intersection of a tangent along the lower border of the mandible and another tangent along the posterior border of the ramus and condyle. All measurements were performed manually by two operators using a protractor and an illuminator. To ensure consistency and reduce bias, the measurements were repeated after a two-week interval on randomly selected radiographs, and inter-observer reliability was assessed. Data were recorded systematically for each participant in a predefined data collection form.

Descriptive statistics, including the mean and standard deviation, were calculated for numerical variables such as age and gonial angle. The gonial angle values obtained from OPGs and lateral cephalograms were compared using Pearson's correlation coefficient to evaluate the strength of the relationship between the two radiographic methods. A one-way analysis of variance (ANOVA) was performed to assess differences in gonial angle measurements between the groups. To evaluate inter-observer reliability, a paired sample t-test was conducted. All statistical analyses were performed using SPSS software, version 25.0 (IBM Corp., Armonk, NY), with a significance threshold set at $p \leq 0.05$.

Efforts were made to minimize methodological bias, including the use of standardized protocols for obtaining radiographs and a rigorous quality control process during measurement and data analysis. The study aimed to ensure robust and reliable results by maintaining high methodological standards, and the findings were interpreted within the context of the study's limitations and the broader literature on the subject.

RESULTS

A total of 200 patients participated in the study, comprising 70 males (35%) with a mean age of 20.00 ± 7.278 years and 130 females (65%) with a mean age of 19.88 ± 6.198 years. The overall mean age of the participants was 19.93 ± 6.643 years. Table 1 provides the gender-wise distribution of patients, including their mean ages and standard deviations.

Table 1: Age Distribution According to Gender

Gender	Number of Patients (%)	Mean Age (Years) ± SD
Male	70 (35%)	20.00 ± 7.278
Female	130 (65%)	19.88 ± 6.198
Total	200 (100%)	19.93 ± 6.643

The gonial angle measurements were obtained for both the right and left sides of the mandible using orthopantomograms (OPG) and lateral cephalograms. The mean gonial angle for males was 124.07° ± 8.60° on the right side and 123.98° ± 8.87° on the left side, as measured on OPGs, with a cephalometric mean of 123.50° ± 9.07°. Similarly, for females, the mean gonial angle on the right side was 124.92° ± 6.96° and 124.49° ± 8.15° on the left side, with a cephalometric mean of 125.26° ± 7.35°. Overall, the mean gonial angle values did not show significant gender-based differences. These measurements are summarized in Table 2.

Table 2: Mean Gonial Angle Measurements on OPG and Lateral Cephalograms by Gender

Gender	Right Gonial Angle (Mean ± SD)	Left Gonial Angle (Mean ± SD)	Cephalometric Gonial Angle (Mean ± SD)
Male	124.07° ± 8.60°	123.98° ± 8.87°	123.50° ± 9.07°
Female	124.92° ± 6.96°	124.49° ± 8.15°	125.26° ± 7.35°
Total	124.62° ± 7.54°	124.31° ± 8.37°	124.65° ± 7.99°

The Pearson correlation coefficient analysis revealed a strong positive correlation between the gonial angle values obtained from OPGs and lateral cephalograms. The correlation coefficient (r) for the right gonial angle was 0.894, while for the left gonial angle, it was 0.898 ($p < 0.01$ for both). This indicates a statistically significant agreement between the two radiographic methods for measuring the gonial angle. These findings are detailed in Table 3.

Table 3: Pearson Correlation Between Gonial Angle Measurements

Measurement Pair	Correlation Coefficient (r)	p-value
Right Gonial Angle (OPG vs Cephalometric)	0.894	<0.01
Left Gonial Angle (OPG vs Cephalometric)	0.898	<0.01

A one-way analysis of variance (ANOVA) was conducted to evaluate differences in gonial angle measurements across the groups. The results indicated no statistically significant differences between the gonial angle values measured on the right and left sides using OPGs and lateral cephalograms. The ANOVA results are summarized in Table 4.

Table 4: Comparison of Gonial Angle Measurements (ANOVA)

Measurement Pair	Mean Square	F-value	p-value
Right Gonial Angle	16.501	0.287	0.593
Left Gonial Angle	5.838	0.083	0.775
Cephalometric Gonial Angle	71.212	1.115	0.294

Inter-observer reliability was assessed using a paired sample t-test, with measurements repeated after a two-week interval. The test yielded a reliability coefficient of 0.887, indicating excellent consistency between observers. This suggests that the manual tracing method used for measuring the gonial angle was highly reproducible.

Overall, the findings demonstrated a significant correlation between gonial angle measurements obtained from OPGs and lateral cephalograms, with no significant differences observed across genders or between the right and left sides. These results validate the reliability of OPGs as an alternative diagnostic tool for assessing the gonial angle in orthodontic practice.

DISCUSSION

The present study evaluated the reliability of orthopantomograms (OPGs) in determining the gonial angle and compared these measurements to those obtained from lateral cephalograms.

The findings demonstrated a strong correlation between the two radiographic methods, suggesting that OPGs provide an accurate alternative for assessing vertical facial growth patterns through gonial angle measurements. This is consistent with earlier studies, which also reported significant agreement between gonial angle measurements obtained from OPGs and lateral cephalograms (9, 11, 13, 14). The study highlighted the potential utility of OPGs as a diagnostic tool in orthodontics, particularly in cases where lateral cephalograms are unavailable or impractical.

The gonial angle is a key cephalometric parameter that reflects vertical growth patterns and mandibular rotation, and its accurate assessment is essential for diagnosing facial asymmetries and developing treatment plans. The results of this study indicated no significant differences between the right and left gonial angle values obtained from OPGs and lateral cephalograms, which is consistent with findings from prior research (6, 14). The high correlation coefficients observed for both sides of the mandible further validated the diagnostic reliability of OPGs, reaffirming their utility in clinical practice. Previous investigations have suggested that OPGs offer clear visualization of the mandibular borders without superimposition, enabling precise angular measurements (12, 16). This advantage aligns with the current findings and supports the adoption of OPGs as a supplementary diagnostic method in orthodontic evaluations.

However, there have been conflicting reports regarding the reliability of OPGs in measuring craniofacial parameters. Some studies have noted that while OPGs are useful for angular measurements, their accuracy for linear dimensions and detailed skeletal assessments is limited compared to lateral cephalograms (6, 15). This discrepancy could be attributed to variations in radiographic techniques, image distortion, or differences in measurement protocols. Despite the strong agreement between OPG and cephalometric measurements in this study, it is important to recognize that OPGs cannot fully replace lateral cephalograms, which provide comprehensive insights into craniofacial structures and growth patterns.

The strengths of this study included its rigorous methodology, the use of standardized radiographic protocols, and the assessment of inter-observer reliability to ensure consistent measurements. The inclusion of a diverse sample with both male and female participants enhanced the generalizability of the findings. Additionally, the use of advanced statistical analyses, such as Pearson correlation and ANOVA, ensured robust evaluation of the data and minimized potential biases.

Nonetheless, the study had some limitations that should be acknowledged. The sample size, while adequate for detecting significant correlations, may not have been large enough to explore subtle variations in gonial angle measurements across different age groups or craniofacial types.

Furthermore, the cross-sectional design limited the ability to assess changes in gonial angle over time or in response to

orthodontic treatment. Another limitation was the reliance on manual tracing for measurements, which, despite high inter-observer reliability, may still introduce minor inconsistencies compared to automated or digital techniques.

Future studies should consider incorporating larger and more diverse populations to evaluate the reliability of OPGs across different demographic groups and craniofacial patterns.

Longitudinal designs could provide valuable insights into the changes in gonial angle associated with growth or orthodontic interventions. Additionally, the use of advanced imaging technologies, such as cone-beam computed tomography (CBCT), could enhance the accuracy of measurements and allow for more comprehensive comparisons with traditional radiographic methods. Given the low radiation dose and wide availability of OPGs, their integration into routine orthodontic diagnostic protocols remains a promising approach for improving patient care while minimizing exposure. The findings of this study demonstrated that OPGs are a reliable alternative to lateral cephalograms for determining gonial angles, particularly in assessing vertical facial growth patterns. While OPGs cannot fully replace lateral cephalograms due to their limitations in providing detailed skeletal assessments, their utility as a diagnostic tool is evident. Future research should aim to address the identified limitations and further refine the use of OPGs in orthodontic and craniofacial evaluations.

CONCLUSION

This study demonstrated a significant correlation between gonial angle measurements obtained from orthopantomograms and lateral cephalograms, confirming the reliability of OPGs as an alternative diagnostic tool for evaluating vertical facial growth patterns.

Given their ease of use, lower radiation exposure, and wide availability, OPGs offer a practical and effective option for routine orthodontic assessments. While they cannot entirely replace lateral cephalograms, their role as a supplementary tool in diagnosing and managing craniofacial discrepancies is invaluable.

These findings have direct implications for improving patient care in orthodontics by enabling accurate, accessible, and minimally invasive diagnostic practices.

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