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***ORIGINAL ARTICLE***

# Reliability of Panoramic Radiography for Vertical Facial Pattern Assessment

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## ABSTRACT

The orthopantomogram (OPG) is a common dental screening radiograph that has multiple implications. However, lateral cephalogram is the investigation of choice for the assessment of vertical facial pattern. **Objective:** The aim of the current study was to investigate the validity of an OPG parameter i.e. panoramic gonial angle (PGoA) for the assessment of the vertical facial pattern. **Methods:** A cross-sectional study was conducted on the pretreatment OPG and lateral cephalograms of 200 orthodontic patients aged 15-40 years. The PGoA was measured on both sides and an average was used for statistical analysis. The Pearson's correlations of PGoA were measured with cephalometric gonial angle (CGoA), SN-GoGn, MMA, FMA, LAFH/TAFH% and PFH/TAFH%. The diagnostic test statistics were applied for PGoA against gold standard "definitive diagnosis (DD)" derived from SN GoGn and FMA. A p-value of <0.05 was taken as statistically significant. **Results:** The mean CGoA was 121.18° ± 5.16° which was significantly different (p <0.001) from the mean PGoA 117.14° ± 4.43°. PGoA was significantly correlated with SN-GoGn, MMA, FMA and CGoA. A standard of PGoA 116°±3° was used to classify subjects into low angle, normal angle and high angle groups. The validity of PGoA with DD showed a sensitivity of 90.32%, 82.72% and 77.78%; and specificity of 95.37%, 84.48% and 91.96% for low angle, normal angle and high angle cases, respectively. **Conclusion:** The current study identifies PGoA as a valid tool for the assessment of vertical facial pattern of orthodontic patients with its normal value 116°±3° in our sample.

**Key words:** cephalometry, lateral cephalogram, orthopantomogram, vertical facial pattern

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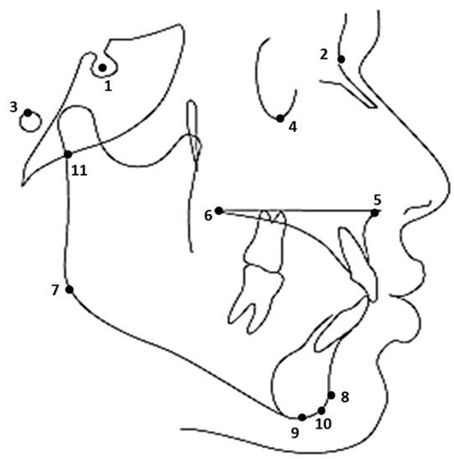
## INTRODUCTION

Orthopantomography (OPG), a screening tool for patients requiring orthodontic treatment, is used to assess the eruption and shedding pattern of deciduous and permanent teeth.[1] OPG allows the evaluation of the number of teeth present, their location and anatomy, and the general health of supporting structures; among its many advantages over other imaging techniques is relatively low radiation exposure.[2] While the quality of images obtained by OPG is relatively poor in the midline, the image definition in the region lateral to the incisors and at the mandibular condyles and ramus is generally considered satisfactory.[3] Lateral cephalogram is another radiographic technique used in orthodontics to assess the vertical and sagittal skeletal growth patterns of a patient. Lateral cephalogram is a standardized radiographic method that provides quantitative data derived from various anatomic landmarks and planes for the evaluation of dental and craniofacial morphology.[3] In contrast to OPG, lateral cephalograms are not always necessary prior to the commencement of orthodontic treatment but are frequently advised for the assessment of vertical and sagittal discrepancies in the craniofacial skeleton.[4]

Various linear and angular cephalometric parameters are used to evaluate the vertical facial patterns of patients, including lower anterior and total anterior facial heights and mandibular plane angles measured in relation to the maxillary plane, Frankfort horizontal plane, and anterior cranial base. Gonial angle is another important parameter representing the divergence of the mandibular plane with respect to the posterior border




Cephalometric Landmarks

| | | |
|---|---|---|
| 1 | Sella (S) | Midpoint of sella turcica |
| 2 | Nasion (N) | Anterior most point on frontonasal suture |
| 3 | Porion (Po) | Posteriosuperior margin of internal auditory meatus |
| 4 | Orbitale (Or) | Anterioinferior margin of orbital cavity |
| 5 | Anterior Nasal Spine (ANS) | Tip of anterior nasal spine of palate |
| 6 | Posterior Nasal Spine (PNS) | Tip of posterior nasal spine at junction of hard and soft palate |
| 7 | Gonion (Go) | Posterioinferior point on angle of mandible |
| 8 | Pogonion (Pog) | Anterior most point on bony chin |
| 9 | Menton (Me) | Inferior most point on bony chin |
| 10 | Gnathion (Gn) | Anterioinferior point on bony chin |

**Figure 1.** Cephalometric landmarks and their definitions used in the current study.

of the ramus.[5] Facial asymmetry, magnification error, orientation errors, and anatomic variations are common factors resulting in dual shadows of the angle of the mandible and ramus on lateral cephalograms. In this context, OPG offers the opportunity to observe and measure the gonial angles of the left and right sides individually and accurately.[6]

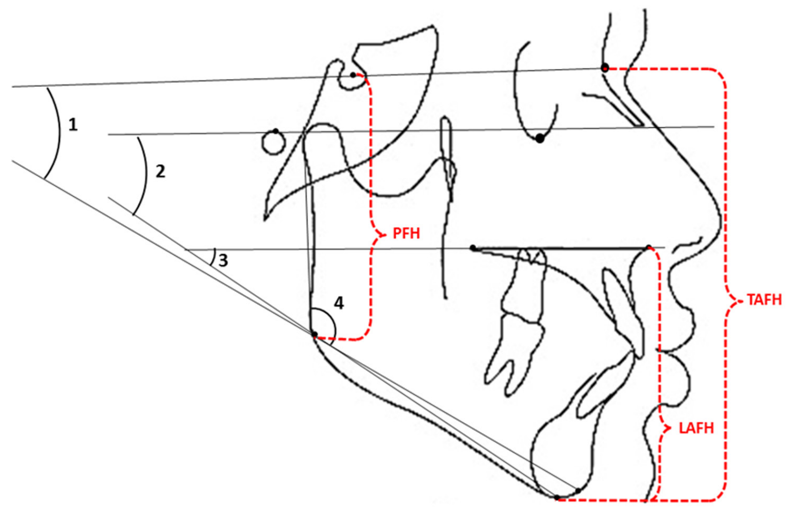
Gonial angles can be measured on OPG with at least the same level of precision as that offered by lateral cephalogram.[6] However, a study reported that the gonial angle measured on OPG may be 2.2°–3.6° smaller than that measured on lateral cephalogram.[7] Several researchers have evaluated the correlation between the gonial angle measured on OPGs and that measured on lateral cephalograms.[7-10] The gonial angle of a patient depicts the mandibular divergence pattern, which is directly related to vertical facial growth. Several vertical cephalometric parameters, such as Steiner's anterior cranial base to mandibular plane (SN-GoGn),[11] Down's Frankfort horizontal plane to mandibular plane (FMA),[12] Schwartz's maxillary mandibular plane (MMA),[13] and Jarabak's ratio and facial height ratio,[14] are established methods used to assess vertical facial pattern. However, the correlation between the panoramic gonial angle (PGoA) and other vertical cephalometric parameters has not been assessed. Because other parameters, such as SN-GoGn, MMA and FMA, are more reliable for assessing vertical facial growth pattern than the cephalometric gonial angle (CGoA), evaluating whether the gonial angles determined by OPG are truly representative of a patient's vertical facial growth pattern is imperative.[15]

The current study aimed to evaluate the correlation between PGoA and CGoA and assess the validity of PGoA for appraising vertical facial patterns with respect to other standard cephalometric parameters.

## METHODS

A cross-sectional study was conducted on the pretreatment OPG and lateral cephalograms of orthodontic patients. The sample size was calculated using the findings of Ganeiber and Bugaighis,[16] who reported a correlation between PGoA and CGoA of 0.897. The alpha was taken as 0.05, and the power of the study was kept at 80%. Under these conditions, the minimum sample required was 105. The sample size was increased to 200 to improve the power of the study further. Ethical authorization and approval for the study were obtained from the Ethical Review Committee of the College of Dentistry, Bakhtawar Amin Medical and Dental College, Multan, prior to data collection.

Good quality radiographic records of orthodontic subjects aged 15–40 years were included in the study.




| | |
|---|---|
| **Angular Measurements** | |
| 1. Sella Nasion - Gonion/Gnathion plane angle (SN-GoGn) | Angle between S-N plane and Go-Gn plane |
| 2. Frankort Horizontal Mandibular plane angle (FMA) | Ange between FH plane and Go-Me plane |
| 3. Maxillary Mandibular plane angle (MMA) | Angle between maxillary plane (ANS-PNS) and Go-Me plane |
| 4. Cephalometric Gonial angle (CGoA) | Angle formed by tangent to posterior border of ramus and Go-Me plane |
| **Linear Measurements** | |
| Total Anterior Facial Height (TAFH) | Distance from N to Me |
| Lower Anterior Facial Height (LAFH) | Distance from ANS to Me |
| Posterior Facial Height (PFH) | Distance from S to Go |

**Figure 2.** Cephalometric linear and angular measurements used in the current study.

Those patients with a history of craniofacial trauma or syndromes or temporomandibular disorders were excluded from this study.

Standardized orthopantomograms and lateral cephalograms were obtained with a FONA XPan DG unit (Assago (MI), Italy). The head was positioned in the natural position for both radiographs. Pretreatment lateral cephalograms were used to evaluate vertical skeletal patterns. The distance from the imaging device to the midsagittal plane of the patient was kept constant at 60 cm, and the distance from the film to the midsagittal plane was kept at 15 cm. Cephalograms were traced by hand on matte acetate paper with a 0.5 mm lead pencil over an illuminator by the principal investigator using the conventional method. Skeletal landmarks were subsequently identified (Figure 1).

The following cephalometric parameters were measured, as described in Figure 2.

1. SN-GoGn: The angle between SN and Steiner's mandibular planes. A norm of 32° ± 4° was taken as the standard.
2. FMA: The angle between FH and the Go-Me plane. A norm of 25° ± 4° was taken as the standard.
3. MMA: The angle between the maxillary and mandibular planes.
4. CGoA: The angle between the tangent to the posterior border of ramus and the line joining the gonion and menton on lateral cephalogram.
5. Total anterior facial height (TAFH): The linear distance between N and M.
6. Lower anterior facial height (LAFH): The linear distance between ANS and Me.
7. Posterior facial height (PFH): The linear distance between S and Go.

PGoAs were measured on both sides, and an average was calculated for each patient (Figure 3).

The lines were traced on tracing paper using a 0.5 mm 2H pencil lead. A protractor with 1° accuracy was used to measure the angles. Thirty randomly selected OPGs and lateral cephalometric radiographs were retraced after a 2-week interval to assess the reproducibility of the measurements. The intraclass correlation coefficient was 0.927, which indicates a good level of agreement between the two measurements.

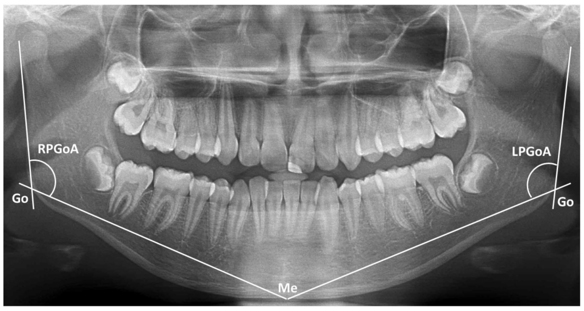



**Figure 3**. Landmarks and measurements on panoramic radiograph. RPGoA – right-sided panoramic gonial angle, LPGoA – left-sided panoramic gonial angle.

**Table 1.** Comparison of various vertical parameters between males and females

| Parameter | Male (n = 92) | Female (n = 108) | p |
|---|---|---|---|
| Sn-GoGn | 30.30° ± 6.87° | 32.31° ± 7.66° | 0.054 |
| CGoA | 121.50° ± 4.84° | 120.90° ± 5.42° | 0.413 |
| PGoA | 117.88° ± 6.05° | 116.52° ± 4.77° | 0.078 |
| MMA | 24.33° ± 5.88° | 24.34° ± 6.82° | 0.986 |
| FMA | 26.17° ± 7.39° | 25.48° ± 6.94° | 0.499 |
| LAFH/ TAFH % | 56.59 ± 4.61 | 56.87 ± 4.61 | 0.667 |
| PFH/ TAFH % | 68.02 ± 5.89 | 66.39 ± 7.28 | 0.087 |

n=200; Independent sample t-test

**Statistical analysis**

Statistical analysis was conducted using the Statistical Package for the Social Sciences (version 25; SPSS, Chicago, IL, USA) software package. Descriptive statistics were used to compute means and standard deviations for age and various panoramic and cephalometric variables. A mean PGoA was calculated for each patient based on the values of the left and right sides. Paired-sample *t*-tests was performed to detect statistically significant discrepancies between the mean CGoA and PGoA. Pearson's correlation coefficient tests were undertaken to assess the correlation among different variables. The validity of PGoA for the diagnosis of three skeletal classes was tested against a gold standard diagnosis derived from SN-GoGn and FMA using diagnostic test statistics. A p-value of <0.05 was taken as statistically significant.

## RESULTS

The study sample comprised 108 females and 92 males. The mean age of the sample was 18.58 ± 5.29 years, the mean right-sided PGoA was 116.95° ± 5.47°, and the meant left-sided PGoA was 117.24° ± 5.29°. Paired-sample *t*-test showed no significant difference between the two sides (p = 0.160). Thus, mean PGoAs were used for further analysis.

All of the parameters were compared between males and females to evaluate gender dimorphism by using independent-sample *t*-test (Table 1). The results showed no significant difference between the two groups.

The mean CGoA was 121.18° ± 5.16°, which was significantly different (p < 0.001) from the mean PGoA (117.14° ± 4.43°) by 4.01°. The correlation between various cephalometric variables and PGoA were evaluated using Pearson's correlation coefficients (Table 2), and results revealed that PGoA was significantly correlated with SN-GoGn, MMA, FMA, and CGoA.

The patients were graded into three groups, i.e., normal angle, high angle, and low angle, according to SN-GoGn, FMA, and PGoA (Table 3). The standards for SN-GoGn, FMA and PGoA were set as 32° ± 4°, 25° ± 4°, and 116° ± 3°, respectively. Patients with values falling below the lower range of these standards were categorized as low angle, while those with values exceeding the upper limit were categorized as high angle.

A total of 61 patients had conflicting diagnosis according to SN GoGn and FMA. Thus, a third group, i.e., "definitive diagnosis (DD)" of vertical facial patterns, was created; this group comprised cases in which both SN-GoGn and FMA gave the same diagnosis. Ahmed et al.[17] showed that SN-GoGn and FMA are the most accurate cephalometric parameters for assessing vertical facial patterns [15]. Thus, the DD group based on these two parameters was treated as the gold standard, and the validity of PGoA was tested against this group. The sensitivities of PGoA for the diagnosis of low-angle, normal-angle, and high-angle cases were 90.32%, 82.72%, and 77.78%, respectively. In addition, the specificities of this parameter for the diagnosis of low-angle, normal-angle, and high-angle cases were 95.37%, 84.48%, and 91.96%, respectively (Table 4).

## DISCUSSION

The current study revealed that PGoA is significantly correlated with different cephalometric parameters used to assess the vertical facial pattern of an individual. The normal value of PGoA may be considered to be 116° ± 3°. This parameter showed adequate sensitivity and specificity for the diagnosis of three different vertical facial patterns.

Assessment of vertical facial pattern is of key interest to orthodontists because such evaluation plays a vital role in the management of malocclusions in the vertical

**Table 2.** Correlation between various vertical parameters (n=200)

| | SN-GoGn | MMA | FMA | LAFH/TAFH% | PFH/TAFH% | CGoA | PGoA |
|---|---|---|---|---|---|---|---|
| SN-GoGn | 1 | 0.799* | 0.717* | 0.084 | −0.636* | 0.269* | 0.259* |
| MMA | 0.799* | 1 | 0.817* | 0.147* | −0.534* | 0.284* | 0.217* |
| FMA | 0.717* | 0.817* | 1 | 0.066 | −0.516* | 0.295* | 0.269* |
| LAFH/TAFH% | 0.084 | 0.147* | 0.066 | 1 | −0.158* | 0.008 | −0.028* |
| PFH/TAFH% | −0.636* | −0.534* | −0.516* | −0.158* | 1 | -0.125 | −0.136* |
| CGoA | 0.269* | 0.284* | 0.295* | 0.008 | −0.125 | 1 | 0.324* |
| PGoA | 0.259* | 0.217* | 0.269* | −0.028 | −0.136 | 0.324* | 1 |

Pearson's correlation coefficients; *p<0.001

**Table 3.** Distribution of subjects into three vertical classes according to different parameters

| | SN GoGn | FMA | DD* | PGoA |
|---|---|---|---|---|
| Low Angle | 48 | 41 | 31 | 42 |
| Normal Angle | 111 | 110 | 81 | 111 |
| High Angle | 41 | 49 | 27 | 47 |
| Total | 200 | 200 | 139 | 200 |

*Definite Diagnosis group = Cases in which SN GoGn and FMA gave the same diagnosis

**Table 4.** Validity of PGoA for the diagnosis of three skeletal classes against the gold standard (i.e., the definitive diagnosis group)

| | Low Angle | | Normal Angle | | High Angle | |
|---|---|---|---|---|---|---|
| | Value | 95% Confidence Interval | Value | 95% Confidence Interval | Value | 95% Confidence Interval |
| Sensitivity | 90.32% | (74.25%–97.96%) | 82.72% | (72.70%–90.22%) | 77.78% | (57.74%–91.38%) |
| Specificity | 95.37% | (89.53%–98.48%) | 84.48% | (72.58%–92.65%) | 91.96% | (85.29%–96.26%) |
| Positive Likelihood Ratio | 19.51 | (8.23–46.28) | 5.33 | (2.90–9.80) | 9.68 | (5.01–18.69) |
| Negative Likelihood Ratio | 0.10 | (0.03–0.30) | 0.20 | (0.13–0.33) | 0.24 | (0.12–0.49) |
| Disease prevalence | 22.30% | (15.68%–30.14%) | 58.27% | (49.61%–66.57%) | 19.42% | (13.21%–26.99%) |
| Positive Predictive Value | 84.85% | (70.25%–93.00%) | 88.16% | (80.20%–93.19%) | 70.00% | (54.71%–81.84%) |
| Negative Predictive Value | 97.17% | (92.13%–99.02%) | 77.78% | (68.22%–85.09%) | 94.50% | (89.43%–97.21%) |
| Accuracy | 94.24% | (88.97%–97.48%) | 83.45% | (76.21%–89.21%) | 89.21% | (82.83%–93.83%) |

plane, such as vertical maxillary excess, open bite, and deep bite.[4] Assessment is usually done on standardized lateral cephalograms by using various cephalometric parameters. The results of the current study highlight the fact that PGoA may be used reliably to detect vertical facial patterns in an individual.

Orthopantomography is based on tomography and prescribed whenever the overall dental health must be investigated. PGoA is subject to changes due to errors in head orientation.[17] In the current study, all OPGs were obtained when the patients' heads were positioned in the natural position. Extension and flexion of the head may alter the PGoA substantially. However, lateral flexion does not significantly alter mean PGoA because increases in GoA on one side lead to a proportional decrease on the other side, which results in no significant difference in average PGoA. Moreover, PGoA, as an angular parameter, is less likely to be affected by magnification errors than other parameters. The results support the opinion of Cobourne and DiBiase[3] that the anatomic structures of the body and ramus of the mandible are not remarkably distorted on OPG that PGoA and CGoA were found to be significantly correlated.

No single cephalometric vertical facial parameter is yet considered a gold standard because some parameters may give conflicting results in the majority of patients. Ahmed et al.[15] demonstrated that SN-GoGn and FMA are the most reliable among various cephalometric vertical facial parameters. SN-GoGn and FMA were not in agreement in 30.5% of our patients. However, in the present study, the authors correlated PGoA with commonly used cephalometric vertical facial parameters and tested its reliability against a gold standard derived from SN-GoGn and FMA.

The use of panoramic radiographs to assess the vertical facial pattern of an individual has been studied by several researchers. Besides Bjork's predictors of vertical facial development, condylar inclination, lower margin of the mandible, and the shape of the inferior alveolar canal may also be studied on panoramic radiographs. However, the reliability of these indicators remains questionable.[18]

A common drawback of OPG is possible image distortion and poor magnification control. Akcam et al.[17] reported only 11%–20% predictability of vertical facial dimensions on OPG; this issue can be minimized significantly if the technique of recording OPG is standardized and angular, rather than linear, measurements are used.

The current study found that PGoA values, on average, measure 3°–4° lower than CGoA values. Fischer–Brandies et al.[7] reported this value to be 2.2°–3.6° in their sample. Although this difference between PGoA and CGoA is statistically significant, a significant positive correlation has been observed between these two angles. A recent study by Radhakrishnan et al.[19] found no difference between PGoA and CGoA in a sample of 50 subjects. Other studies[7,8,10,20] also reported that these two measurements correlate with each other. The vertical facial pattern is most frequently reported using the mandibular plane as reference.[11-13] The divergence of the mandibular plane has been shown to influence the facial profile, lip competency, and inclination of the lower incisors.[16,20] The results of the current study support the reliability of PGoA and may advocate its use, where mandated, because it is also based on the mandibular plane divergence assessed with reference to the posterior border of the ramus. OPG is commonly used a screening tool for assessing the eruption and shedding pattern of teeth in children. The diagnosis of an abnormal vertical growth pattern utilizing PGoA at an early age may help in the selection of conservative treatment modalities to reduce the need for additional radiation exposure and the associated costs.

## CONCLUSION

The current study identified PGoA as a valid panoramic parameter to assess the vertical facial pattern of an individual with satisfactory accuracy. The mean PGoA was found to be significantly correlated with different cephalometric parameters, such as SN-GoGn, MMA, FMA, and CGoA. Considering a normal value of 116° ± 3°, the sensitivities of PGoA for the diagnosis of low-angle, normal-angle, and high-angle cases were 90.32%, 82.72%, and 77.78%, respectively. Moreover, the specificities of this parameter for the diagnosis of low-angle, normal-angle, and high-angle cases were 95.37%, 84.48%, and 91.96%, respectively.

## CONFLICT OF INTEREST

All author declared no conflict of interests.

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