Original Article

Coefficient of regression to predict skeletal patterns for nongrowing subjects using gonial angle on orthopantomogram

ABSTRACT

Introduction: The gonial angle plays to be one of the significant indicators for the diagnosis of growth pattern of orthodontic patients. It is a known fact that lateral cephalograms are commonly used for the measurement of gonial angle, but panoramic radiographs (PRs) can display both the gonial angles simultaneously and as accurately as lateral cephalograms. The aim of this study is to develop an equation for the prediction of the skeletal pattern of nongrowing participants from gonial angle values on PR.

Materials and Methods: PRs and lateral cephalograms of 75 orthodontic patients were selected. The gonial angle was measured on PR and Sella Nasion-mandibular plane (SN-MP) angle was measured on lateral cephalograms. The values obtained were analyzed using paired Pearson's correlation test and regression analysis was done.

Results: The relationship between the gonial angle measurements obtained from each radiograph was represented as, "SN-MP angle (Skeletal pattern) = −44.297 + 0.6318 Gonial angle (PR) in the linear function."

Conclusion: Hence, PR could be used to determine the gonial angle as accurately as a lateral cephalogram and a useful tool for examining the skeletal pattern of patients.

Keywords: Gonial angle, lateral cephalogram, orthodontic diagnosis, orthopantomogram

INTRODUCTION

Panoramic radiographs (PRs) were first employed in dentistry by Paatero in 1961.[1] PR is frequently used in dental practice to provide detailed information about the temporomandibular joint, neoplasm, cyst, eruption of the teeth, their axial inclinations, maturation periods, and surrounding tissues on a single radiograph with low radiation dose. Therefore, PR seems to be irreplaceable as an orthodontic screening tool.[2] Although the lateral cephalograms provide a lot of information regarding the craniofacial structures, it is impossible to accurately visualize the right and left sides of these structures in a single radiograph because of the superimposition of the two sides. Since the structures of both sides are clearly visible on the PR, it could be used for the evaluation of the bilateral structures. Sharma *et al.*[3] have found a significant correlation between posterior mandibular height and angular parameters for mandibular length and ramus length in growing patients. In orthodontics, rotation

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of the mandible is commonly determined by the gonial angle.[4] Patients with the downward and backward rotation of mandible are considered as "high-angle" patients as they display increased gonial angles. Whereas, decreased gonial angles and a display of upward and forward direction of the mandible is seen with "low-angle" patients.[5] The gonial angle also plays to be one of the significant indicators for the diagnosis of the vertical growth pattern of orthodontic patients. It is a known fact that lateral cephalograms are commonly used for the measurement of gonial angle, but PRs can display both the gonial angles simultaneously and as accurately as lateral cephalograms.[6]

Although studies have investigated the skeletal patterns in relation to different angular measurements with the help of lateral cephalograms.[6,7] Only a few studies investigating the skeletal pattern of nongrowing patients with the help of PRs have been conducted,[8,9] none of the studies have investigated the dentoskeletal growth pattern of the patient using only PR. Hence, further research is needed to establish the use of PRs in orthodontics to predict skeletal pattern that will limit the need for lateral cephalograms. Therefore, the aim of this study was to assess whether a correlation exists between gonial angle measurement values and skeletal patterns in PRs and to develop an equation for the prediction of the skeletal pattern of nongrowing subjects from gonial angle values on PR alone, to enhance the applicability of PR as an orthodontic diagnostic tool and reduce the patient exposure to radiation due to a subsequent radiograph.

MATERIALS AND METHODS

The present study was conducted according to the declaration of Helsinki of 1975 as revised in 2000. The study was conducted on the pretreatment PRs and lateral cephalograms of total of 75 subjects between the age group of 18 and 25 years with the mean age 21.5 were selected from the ongoing patients in the Department of Orthodontics and Dentofacial Orthopedics. Written consent was taken from each participant of the study. The 75 participants were selected on the basis of sella nasion (SN)-mandibular plane (MP) angle to equally represent each type of skeletal pattern in this study that is normodivergent, hypodivergent, and hyperdivergent. The inclusion criteria were nongrowing patients in the age group of 18–25 years, subject with fully erupted permanent first molars and central incisors at the time of initial investigation, and subjects with intact permanent dentition. The exclusion criteria were subjects with history of prior orthodontic treatment, radiographs with poor sharpness and resolution, growing patients, subjects with oligodontia or multiple tooth agenesis, any history of bone deformities or bone diseases and major illness in the past and subjects with congenital abnormalities affecting growth and development.

PRs and lateral cephalograms were taken using Sirona Dentsply Machine, ORTHOPHOS XG 3D MANUFACTURED by SIRONA (Gallelios, Germany) by the same radiographer with the Frankfort horizontal plane parallel to the floor and according to the manufacturers' operating instructions. As the sample size was limited, only single examiner carried out the tracing procedure to eliminate inter-examiner variability and for measurements on the PRs and lateral cephalograms, tracings were made for both the left and right sides to overcome any magnification error. To eliminate intraexaminer bias, ten lateral cephalograms were randomly selected and re-traced. Landmark location, tracing and angular measurements were assessed for error. Angular measurement errors were found to average a value of 0.5˚.The interclass correlation coefficient was found to be 0.87 indicating excellent agreement. Hence, proceeded with the study.

The radiographs were traced and analyzed using a modified cephalometric analysis based on comparable reference points, which could be located on both the lateral cephalogram and the PR. Following landmarks, lines and planes were used in the study [Figures 1 and 2].

Panoramic and cephalometric landmarks on panoramic radiograph and Lateral Cephalogram (LCR)

- Condylion dorsale (Cod) (PR and Lateral Cephalogram [LCR]): Most posterior point of the condyle
- Gonial tangent point (Go) (PR and LCR): Intersection of a tangent to the posterior border of the ramus through the Cod and a tangent through corpus tangent point (Tgc) and gnathion (Gn)
- Tgc (corpus tangent point) (PR): Contact point in the gonial area of the tangent to the lower mandibular border, which runs through point gnathion (Gn)
- Menton (Me) (PR): Most inferior point of the contour of the bony chin in the median plane
- Gnathion (Gn) (PR): Most inferior point of the mandible in the canine region of each side
- Pogonion (Pog) (LCR): Most projecting point on the anterior surface of chin
- Sella (S) (LCR): Midpoint of pituitary fossa
- Nasion (N) (LCR): Most anterior point on the frontonasal suture that joins the nasal part of the frontal bone and nasal bone.

Reference lines and planes

- Mandibular line (ML) (PR and LCR): This line extends through gnathion (Gn) and corpus tangent point (Tgc)

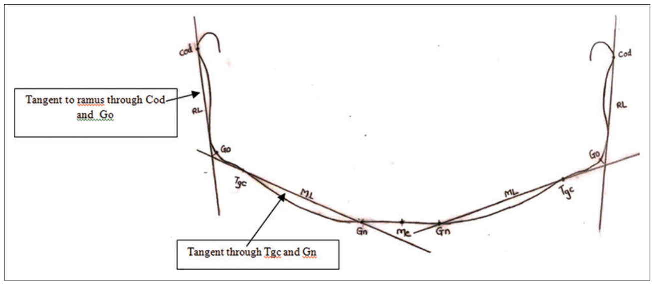

Figure 1: Panoramic radiograph with landmarks, planes and angle

- RL (Ramus tangent) (PR and LCR): Line constructed between tangent to the posterior border of the ramus through Cod
- SN (plane) (LCR): This line extends through the sella (S) point and nasion (N) point on LCR
- With the help of above-mentioned lines and planes, following angular measurements were used in the study
- ML/RL (gonial angle) (PR and LCR): Angle formed between the ML and ramus tangent (RL)
- SN-MP (mandibular plane angle) (LCR): Angle formed by relating MP (ML) to anterior cranial base (SN).

On the lateral cephalogram, for the bilateral structures, the mean outlines were used for locating the landmarks. On the PR, reference points were located separately for the left and right sides. Separate measurements on the right and left sides were taken on the PR and the mean was taken for any differences. The angular measurements were made on PRs and lateral cephalograms to the nearest 0.5° with the help of a transparent millimeter ruler and a protractor, respectively.

RESULTS

The mean values and standard deviations of the parameters were calculated for PRs and lateral cephalograms. SPSS 18 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis was used for the statistical analysis. The Pearson's correlation coefficient (ρ) between mean values of gonial angle and skeletal pattern in PRs was 0.7823 [Table 1] with $P < 0.001$ indicating significant positive correlation. Linear regression analysis was done with PRs and skeletal pattern (normodivergent, hypodivergent, and hyperdivergent) and the relationship between the gonial angle measurements obtained from each radiograph was represented as, "SN-MP angle (Skeletal pattern) = −44.297 + 0.6318 × Gonial angle (panoramic radiogaph) in the linear function."

The r^2 value for linear regression analysis is 0.5913 indicating strong association between SN-MP angle and gonial angle value on PR.

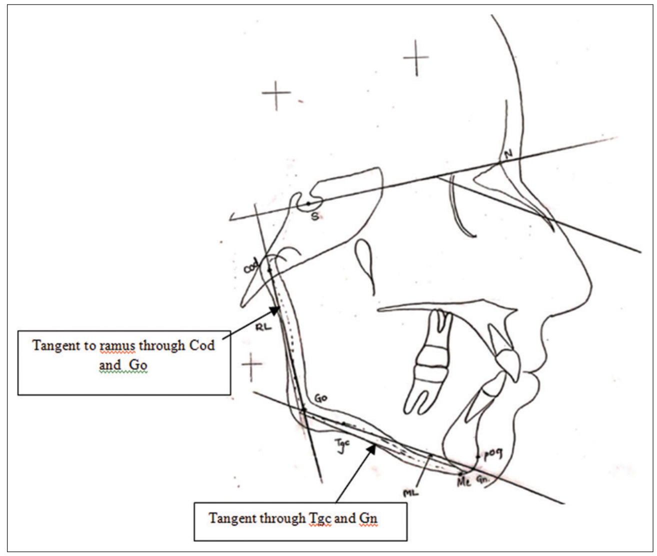

Figure 2: Lateral cephalogram (LCR) with landmarks, planes and angles

Table 1: Mean, standard deviation, range, and correlation coefficient of panoramic radiographic and cephalometric values with sella nasion-mandibular plane angle

	n	Correlation coefficient	Mean±SD	SE mean	95% CI	
					Lower	Upper
GoA-LCR	75	0.7690	123.97±7.692	0.8882	122.20	125.75
GoA-PR	75	0.7823	118.14±8.790	1.015	116.12	120.17

SD: Standard deviation, SE: Standard error, CI: Confidence interval, LCR: Lateral cephalogram, GoA-LCR: Gonial angle on Lateral cephalograms, GoA-PR: GoA on panoramic radiograph

DISCUSSION

Lateral cephalograms and PRs are referred by 90% of orthodontists for the patients with permanent dentition seeking orthodontic therapy.[9] These are the foremost valuable, inevitable aids for obtaining a complete overall radiographic assessment of patients to be treated by orthodontic therapy. Although lateral cephalograms are irreplaceable tools in orthodontic treatment planning, it is not used for evaluating the pathology of teeth and surrounding tissues. The disbenefit of superimposition of bilateral structures with each other in lateral cephalograms leads to variations in the landmarks used for measurement of articular angle and gonial angle.[10]

In between both of these extra-oral radiography methods, the PRs are routinely referred by dental practitioners during the initial stages of diagnosis and treatment planning and form the basis of an overall dental assessment. Often clinical examination supplemented by study models with reduced number of radiographs taken are sufficient for the purpose of orthodontic treatment planning,[11] and this reduction in number of radiographs taken will not only be beneficial for the patient biologically but also serves as a cost-effective measure. Therefore, this study tried to enhance the clinical versatility of PR by using it to predict dentoskeletal patterns in nongrowing patients using linear regression analysis, thereby eliminating the need for additional radiographs just for the assessment of growth pattern.

In this present study, PR was selected for gonial angle determination since both the right and the left gonial angle can be easily measured individually from PR, without affecting the accuracy of measurement due image superimposition as with lateral cephalograms.[12,13] The gonial angle measurement is a significant indicator to assess rotation of the mandible and vertical growth pattern,[14] and thereby categorized as "high-angle" patient or low angle patient.[4] Hence, consideration of gonial angle measurement is important in formulating an appropriate orthodontic treatment plan. This method was supported by the study conducted by Bhullar *et al.*[6] that compared and determined the gonial angle and also assessed the gendered differences for gonial angle from cephalograms and orthopantamograms and did not observe any statistically significant differences between lateral cephalogram and PR for the determination of gonial angle measurement values.

In support, studies conducted by Akcam *et al.*[15] and Larheim and Svanaes[16] observed that angular measurements are more reliable when measured on PR, and that the mean value of the gonial angle computed from a PR was nearly equal to that measured on the mandible of a dried skull. Of the three commonly used MPs used in measuring gonial angle, the values obtained with tweed MP are more reliable according to study conducted by Nadkerny *et al.*[17,18] However, it also presents a drawback of image distortion and magnification especially in anterior region, although magnification factor is given by manufacturer, it is not uniform in all locations.[19]

In this present study, the values of gonial angle on PRs showed a high positive degree of correlation with SN-MP angle indicating PRs can be used to determine the skeletal patterns instead of going for conventional lateral cephalograms. This might be attributed to more accurate determination of gonial angles of both the sides without superimposition and minimal distortion of the posterior part of mandible in PR.

One of the first attempts to determine skeletal pattern using PRs was undertaken by Levandoski[20] and since then, very few studies have demonstrated the use of PRs to determine growth pattern as per our knowledge,[8,15] The present study is one of a kind to develop a regression equation that will help in predicting the SN-MP angle based on PR alone by simply substituting the gonial angle measurement value obtained from PR and will serve as an faster, easier, and more economical way of determining the skeletal pattern of the patient.

The reliability of PR in orthodontics has been previously supported by a study conducted by Katti *et al*.[21] that assessed the gonial angles on cephalograms and orthopantomograms in Angle's Class I malocclusion and found no statistically significant difference between the two. The interpretation of the present study adds upon the existing literature leaning more towards reducing the number of radiographs, it also enlightens a new dimension in use of PR to determine growth pattern of patient for orthodontic treatment approach.

However, in the present study, the analysis was limited to the nongrowers only and further research is required to find the correlation in the growing patient. In future, the correlation of linear and angular measurements using PR should be focused upon to establish the use of PRs for determining the skeletal pattern as well as growth pattern in orthodontic patients.

CONCLUSION

Based on the obtained results of this study, it can be concluded that PR is as accurate and effective as a lateral cephalogram for the determination of the gonial angle of orthodontic patients. The relationship between the gonial angle measurements obtained from each was represented as SN-MP angle (Skeletal pattern) $= -44.297 + 0.6318 \times$ Gonial angle (PR) in the linear function.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Bibi T, Rasool G, Khan MH. Reliability of orthopantomogram in determination of gonial angle. Pak Oral Dent J 2017;37:248-51.
2. Graber TM. Panoramic radiography in orthodontic diagnosis. Am J Orthod 1967;53:799-821.
3. Sharma VK, Tondon V, Singh GK. Evaluation of skeletal patterns using panoramic radiography. J Adv Res Dent Oral 2017;2:1-8.
4. Sassouni V, Nanda S. Analysis of dentofacial vertical proportions. Am J Orthod Dentofacial Orthop 1964;50:801-23.
5. Xiao D, Gao H, Ren Y. Craniofacial morphological characteristics of Chinese adults with normal occlusion and different skeletal divergence. Eur J Orthod 2011;33:198-204.
6. Bhullar MK, Uppal AS, Kochhar GK, Chachra S, Kochhar AS. Comparison of gonial angle determination from cephalograms and

orthopantomogram. Indian J Dent 2014;5:123-6.
7. Ahmed M, Shaikh A, Fida M. Diagnostic performance of various cephalometric parameters for the assessment of vertical growth pattern. Dental Press J Orthod 2016;21:41-9.
8. Puri T. Panoramic radiographs for investigating skeletal patterns. Int J Dent Res 2019;4:66-78.
9. Atchison KA. Radiographic examinations of orthodontic educators and practitioners. J Dent Educ 1986;50:651-5.
10. Appasaheb N, Smitha K, Roshan SN, Sathish KS. Diagnistic limitations of cephalometrics in orthodontics. J Dent Med Sci 2012;3:30-5.
11. Han UK, Vig KW, Weintraub JA, Vig PS, Kowalski CJ. Consistency of orthodontic treatment decisions relative to diagnostic records. Am J Orthod Dentofacial Orthop 1991;100:212-9.
12. Mattila K, Altonen M, Haavikko K. Determination of the gonial angle from the orthopantomogram. Angle Orthod 1977;47:107-10.
13. Zangouei-Booshehri M, Aghili HA, Abasi M, Ezoddini-Ardakani F. Agreement between panoramic and lateral cephalometric radiographs for measuring the gonial angle. Iran J Radiol 2012;9:178-82.
14. Tronje G, Welander U, McDavid WD, Morris CR. Image distortion in rotational panoramic radiography. III. Inclined objects. Acta Radiol Diagn (Stockh) 1981;22:585-92.
15. Akcam MO, Altiok T, Ozdiler E. Panoramic radiographs: A tool for investigating skeletal pattern. Am J Orthod Dentofacial Orthop 2003;123:175-81.
16. Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: Mandibular linear dimensions and angles. Am J Orthod Dentofacial Orthop 1986;90:45-51.
17. Nadkerny V, Thilagarani PV, Kumar D, Nadkerny P. Assessing reliability of mandibular planes in determining gonial angle on lateral cephalogram and panoramic radiograph. J Orthod Res 2015;3:45-8.
18. Majeed M, Ahmed I. Comparison of gonial angle determination from cephalograms and orthopantomogram of patients under orthodontic treatment. J Bahria Univ Med Dent Coll 2016;6:88-91.
19. Arora H, Jain V, Pai KM, Kamboj R. Precision of dimensional measurements of mandible in different positions on orthopantomogram. Indian J Dent Res 2013;24:48-51.
20. Piedra I. The levandoski panoramic analysis in the diagnosis of facial and dental asymmetries. J Clin Pediatr Dent 1995;20:15-21.
21. Katti G, Katti C, Shahbaz S, Khan M, Ghali SR. Reliability of panoramic radiography in assessing gonial angle compared to lateral cephalogram in adult patients with Class I malocclusion. J Indian Acad Oral Med Radiol 2016;28:252-5.