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ORIGINAL RESEARCH

Accuracy of Gonial Angle Measurements Using Panoramic Imaging versus Lateral Cephalograms in Adults with Different Mandibular Divergence Patterns

Nada E Tashkandi[1], Najla Hamad Alnaqa[2], Naif M Al-Saif[3], Eman Allam[4]

[1]Preventative Department, Riyadh Elm University, Riyadh, Saudi Arabia; [2]Riyadh Elm University, Riyadh, Saudi Arabia; [3]King Saud University, Riyadh, Saudi Arabia; [4]Basic Dental Science Department, Oral and Dental Research Institute, National Research Centre, Cairo, Egypt

Correspondence: Nada E Tashkandi, Preventative Department, Riyadh Elm University, Riyadh, Saudi Arabia, Email nada.tashkandi@riyadh.edu.sa

Introduction: Gonial angle is an important craniofacial parameter providing information about symmetry and vertical dimensions of the facial skeleton. It can be measured on panoramic radiographs and lateral cephalograms. Reliable assessment of the gonial angle is challenged by the superimpositions associated with lateral cephalograms. The aim of the current study was to assess the precision of panoramic imaging in measuring the gonial angles compared to lateral cephalograms in adult patients with different mandibular divergence patterns.

Methods: Panoramic radiographs and lateral cephalograms of 448 adults (18–30 years old) were utilized in the study. The gonial angle was determined on the lateral cephalograms using an online AI-driven assessment tool (WebCeph^{TM}) and compared to the panoramic measurements among the different gender, malocclusion, and mandibular divergence groups.

Results: Statistically significant differences were recorded between measurements taken on lateral cephalograms or panoramic radiographs (p=0.022). In addition, statistically significant differences were reported in gonial angle measurements on panoramic radiographs among the different mandibular divergence groups (p=0.004) for FMA (p=0.002) for Sn-GoMe.

Conclusion: While cephalometry is considered the gold standard tool for reliable gonial angle assessment, panoramic radiographs were more accurate in detecting the differences between the divergence groups in the current study.

Keywords: mandibular divergence, gonial angle, panoramic radiography, cephalometry

Introduction

A comprehensive patient assessment is essential to the success of orthodontic treatment and dental care. During diagnosis and treatment planning, a thorough assessment of the occlusion, soft tissue relationships, and the skeletal form is necessary. Clinical examination, patient's photographs, dental casts, and radiographs are typically used for this purpose.[1–3] Panoramic radiographs constitute an integral part of the standard of care in dentistry. It is used by dentists and orthodontists alike offering wide panoramic visualization of the maxillofacial region. They serve as invaluable screening tools for detecting abnormalities in the teeth and alveolar bone including diagnosis of cysts or tumours, dental anomalies, tooth eruption paths, bone pathology, and mandibular asymmetry. Its non-invasive nature, reduced radiation exposure, affordability, and ability to showcase the entire dentition, temporomandibular joints, and surrounding anatomy make panoramic radiographs an integral part in modern dental practice. For many clinicians, it is an adequate tool to guide a well-informed decision for a treatment plan.[4,5]

Similarly, lateral cephalometric radiographs are widely used as a screening tool for orthodontic diagnosis and treatment planning and are considered another cornerstone in the field of diagnostic dentistry. It provides a detailed profile of the skeletal disproportion associated with malocclusions and facilitates the prediction of future growth changes in the craniofacial structures. Lateral cephalometric radiographs show a sagittal view of the skeletal, soft tissues, and

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dental structures. For lateral cephalometric evaluations, certain anatomical landmarks and points on the skull are used to allow quantitative analyses and measurements.[6,7]

The gonial angle, a critical metric in craniofacial analysis, is defined as the angle formed by the convergence of two reference lines: one extending from the midpoint of the mandibular ramus to the mandibular body, and the other extending from the mandibular body to the lower border of the mandible. This angular measurement is crucial in assessing mandibular morphology and skeletal relationships. When making cephalometric measurements from radiographs, lateral and anteroposterior projections are typically utilized. However, accurate measurements of an individual's gonial angle become challenging due to superimpositions on the lateral cephalograms.[8–10] The aim of the current study was to assess the precision of panoramic imaging in measuring the gonial angles compared to lateral cephalograms in adult patients with different mandibular divergence patterns.

Materials and Methods

Panoramic radiographs and lateral cephalograms of 448 adults (241 females and 207 males, 18–30 years old) were selected from the orthodontic records archive at the Postgraduate Clinics of Riyadh Elm University, Riyadh, KSA. All radiographs were classified as pre-treatment records of patients currently undergoing orthodontic treatment in the same facility, identified as non-growing subjects, no medical conditions, and no history of surgery or trauma involving the mandible. Radiographs were excluded if the records indicated that subjects had any syndromes, skeletal or facial anomalies, missing teeth (other than the 3rd molars), history of previous orthodontic treatment, or if the radiograph showed any technical or exposure errors or were not taken at the same timepoint. All participants provided written informed consent and the study was approved by the Institutional Review Board of Riyadh Elm University (FRP/226224220).

All collected cephalometric radiographs were traced using the WebCeph^{TM} program (AssembleCircle Corp., Gyeonggi-do, Republic of Korea) which utilizes AI in tracing. Anatomical landmarks were identified and located by the software and checked manually so that lines and angles could be drawn and measured. Measurements on the lateral cephalograms included, the gonial angle, ANB angle, Frankfort-mandibular plane angle (FMA), and mandibular plane to cranial base (SN-GoMe) (Table 1). On the panoramic radiograph, the gonial angle was measured by intersection of the posterior ramal border and the tangent to the inferior border of the mandible. All measurements were taken and reviewed individually by two calibrated examiners (Figures 1 and 2).

Anteroposterior classification of the sample (according to the ANB angle) revealed a distribution as follows: Class I (n=75, 16.74%), Class II (n=282, 62.94%), and Class III (n=91, 20.3%). Vertically, based on the FMA values, the sample was classified as: hypodivergents (n=87, 19.4%), normodivergents (n=161, 35.93%) and hyperdivergents (n=200, 44.6%) cases. However, the percentages changed slightly when considering the Sn-GoMe rendering a classification of: hypodivergents (n=63, 14.06%), normodivergents (n=170, 37.94%) and hyperdivergents (n=215, 47.99%) cases.

Table 1 Anatomical Landmarks, Lines, and Angles Used in the Study

Landmarks and lines	
Sella-Nasion (SN)	Line extended from sella point to the nasion point
Nasion-A point (NA)	Line extended from nasion point to A point
Nasion-B point (SN)	Line extended rom nasion point to B point
Frankfort Horizontal (FH)	Line extended from orbitale point to porion point
Mandibular plane	Line extended form gonion point (Go) to menton point (Me)
Angles	
ANB	The difference between SNA and SNB. Indicates the relation of the jaws to each other and is used to classify patients as Class I (within normal range), Class II (above normal range) or Class III (below normal range)
SN-GoMe	The angle between the cranial base and the mandibular plane. Indicates a hyper- or hypo-divergent mandible
FMA	The angle between the FH and mandibular plane. Indicates a hyper- or hypo-divergent mandible
Gonial angle	The angle between the posterior border of the ramus and the mandible plane.

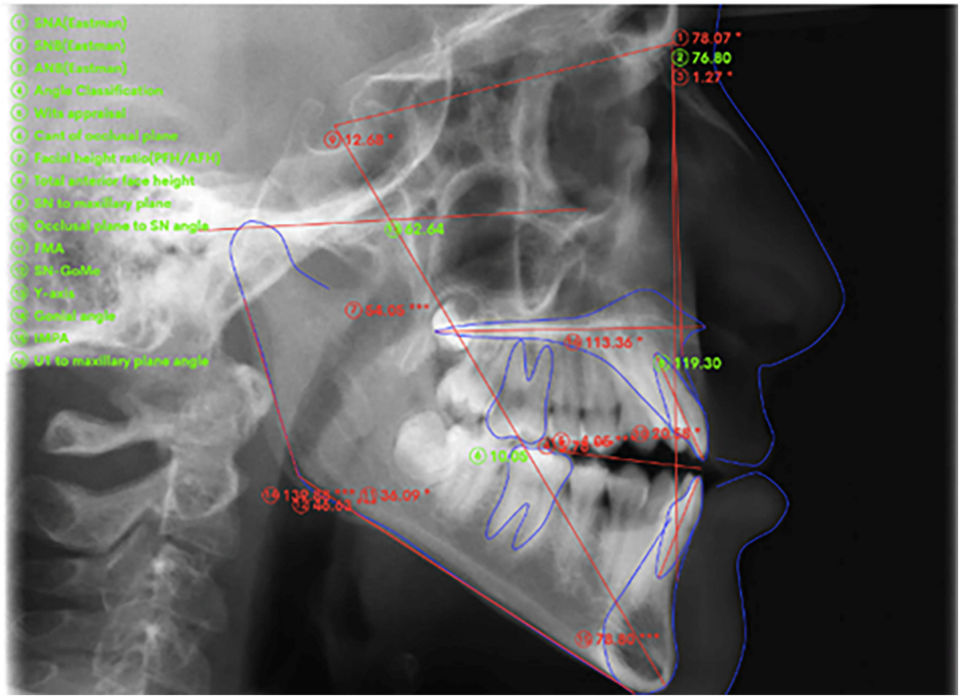

Figure 1 Lateral cephalogram showing the landmarks locations and measurements made using WebCeph.

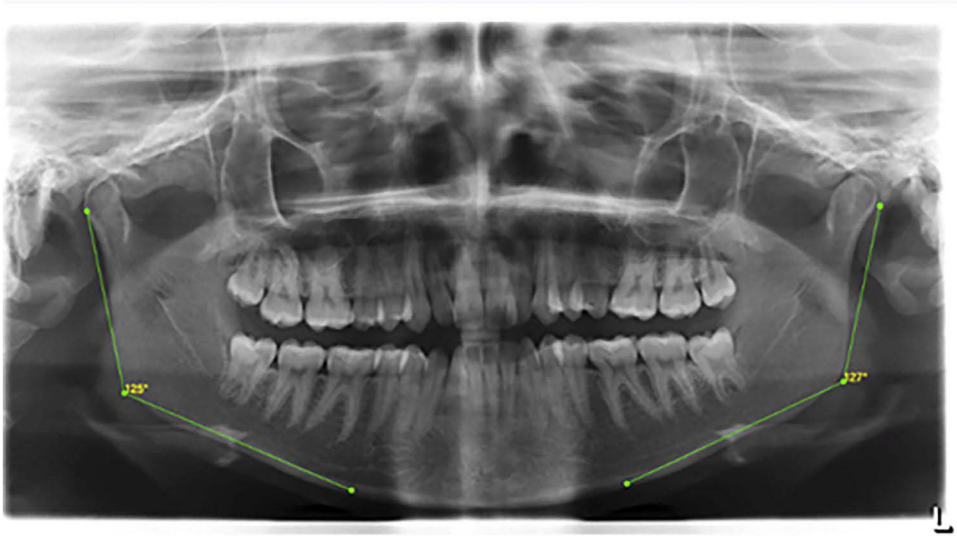

Figure 2 Gonial angle measured on a panoramic radiograph.

Statistical Analysis

The sample size needed for conducting this study was calculated using the G*Power 3.1 software. The measurements were recorded by the primary investigator for 100 cases and repeated after an interval period of 2 weeks by the same investigator to assess intrarater reliability. The same measurements were recorded by another investigator using the same protocol to assess the interrater reliability. The measurement errors were assessed by Dahlberg's method and intraclass correlation coefficient (ICC) was used to assess reliability. Data was analysed using IBM-SPSS for Windows version 28.0 (SPSS Inc., Chicago, IL). One-way analysis of variance (ANOVA) and regression analysis were used for the comparisons. A p-value of less than 0.05 was considered significant.

Results

The intra- and inter-examiner reliability tests showed no statistically significant differences between readings and excellent reliability for all measurements (ICC ≥ 0.90). Since panoramic measurements of the right and left gonial angles were very high correlated (ICC = 0.968), the average was calculated and compared to the cephalometric gonial angle values.

No statistically significant differences were recorded for the gonial angle measurements taken on lateral cephalograms or panoramic radiographs between both genders (p=0.379 and p=0.116 respectively, Table 2). However, comparison of the gonial angle measurements between lateral cephalograms and panoramic radiographs showed statistically significant difference (p=0.022, Table 3).

Statistically significant differences were reported in gonial angle measurements on panoramic radiographs among different mandibular divergence groups (p=0.004) for FMA (p=0.002) for Sn-GoMe (Tables 4 and 5). Nonetheless, gonial angle measurements were non-significantly different when compared between the lateral cephalograms and panoramic radiographs among different malocclusions (Table 6).

Table 2 Descriptive Statistics and Comparison of the Gonial Angle Measurements on Lateral Cephalograms and Panoramic Radiographs Between Both Genders (Significant at P≤0.05)

Radiograph Type	Gender	Gonial Angle (°)	P-value
Lateral cephalograms	Male Female	126.052 ± 6.943 128.159 ± 6.701	0.379
Panoramic radiographs	Male Female	129.480 ± 6.864 130.670 ± 6.803	0.116

Table 3 Comparison of the Gonial Angle Measurements on Lateral Cephalograms and Panoramic Radiographs

Radiograph Type	Gonial Angle (°)	P-value
Lateral cephalograms	127.185 ± 6.887	0.022*
Panoramic radiographs (avg)	130.120 ± 6.849	

Note: *Significant at p≤0.05.

Table 4 Comparison of Gonial Angle Measurements Between the Lateral Cephalograms and Panoramic Radiographs Among Different Mandibular Divergence Groups (FMA)

Radiograph Type	Mandibular Divergence	Gender		P-value
		No. of Male	No. of Female	
Lateral cephalograms	Normal Hypo – divergent Hyper – divergent	91 (44%) 32 (15%) 84 (41%)	79 (33%) 31 (13%) 131 (54%)	0.317
Panoramic radiographs (avg)	Normal Hypo – divergent Hyper – divergent	91 (44%) 32 (15%) 84 (41%)	79 (33%) 31 (13%) 131 (54%)	0.004*

Note: *Significant at p≤0.05.

Table 5 Comparison of Gonial Angle Measurements Between the Lateral Cephalograms and Panoramic Radiographs Among Different Mandibular Divergence Groups (Sn-GoMe)

Radiograph Type	Mandibular Divergence	Gender		P-value
		No. of Male	No. of Female	
Lateral cephalograms	Normal Hypo - divergent Hyper - divergent	82 (40%) 41 (19%) 84 (41%)	79 (33%) 46 (19%) 116 (48%)	0.291
Panoramic radiographs (avg)	Normal Hypo - divergent Hyper - divergent	82 (40%) 41 (19%) 84 (41%)	79 (33%) 46 (19%) 116 (48%)	0.002*

Note: *Significant at p≤0.05.

Table 6 Comparison of Gonial Angle Measurements Between the Lateral Cephalograms and Panoramic Radiographs Among Different Malocclusions. Significant at P≤0.05

Radiograph Type	Malocclusion	Gender		P-value
		No. of Male	No. of Female	
Lateral cephalograms	Class I Class II Class III	38 (18%) 111 (54%) 58 (28%)	37 (15%) 171 (71%) 33 (14%)	0.421
Panoramic radiographs (avg)	Class I Class II Class III	38 (18%) 111 (54%) 58 (28%)	37 (15%) 171 (71%) 33 (14%)	0.390

Discussion

The gonial angle radiographic measurement is frequently used in dentistry as an indicator to determine the growth pattern of subjects and to specify the rotation of the mandible. It is also an important parameter for assessing facial asymmetry.[11] Gonial angle measurements are also utilized for age prediction in circumstances such as a mass catastrophe, human remains, and missing persons.[12] Increased gonial angle indicates downward and backward rotation of the mandible (high angle) while decreased gonial angle indicate 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.[13,14] The aim of the current study was to investigate the accuracy of panoramic imaging in measuring the gonial angles compared to lateral cephalograms in adult patients with different mandibular divergence patterns.

When comparing panoramic and lateral cephalograms, it is crucial to acknowledge the distinctions of their respective digital imaging techniques and the principles of tridimensional geometry that underlie their acquisition. These differences cause potential biases inherent in their interpretation. Even though they are two-dimensional, panoramic photographs depict structures from different perspectives, requiring a grasp of 3D concepts to accurately interpret them. Conversely, lateral cephalograms provide a more direct representation of sagittal relationships but still necessitate an understanding of 3D craniofacial morphology to contextualize their findings. These inherent differences emphasize the importance of considering potential biases when interpreting radiographic findings. Other factors such as patient positioning, anatomical variations, and technical limitations can also contribute to biases in image quality and interpretation. Clinicians must be aware of the impact of all these factors to ensure accurate diagnoses and treatment planning especially for their orthodontics and oral surgery cases.[15,16]

WebCeph is an online AI-based platform developed to provide cephalometric applications and allow automatic tracings and analysis. Its use has grown significantly in popularity, particularly among orthodontists and orthognathic surgeons. It offers automatic superimposition, treatment simulation, and manual landmark editing while automating measurement computation.[17] WebCeph reliability, performance, and accuracy have been assessed previously with

conflicting results. While some studies indicated its suitability for clinical uses and research purposes highlighting advantages such as convenience of digital imaging in terms of storage, enhancement, and transmission quality, other reports indicated problems related to inconsistency of measurements.[18–20] In the current study, WebCeph was used to perform cephalometric tracing and analysis of the gonial angle.

The results of the study demonstrate that there are statistically significant differences in the values of gonial angle measured on cephalograms and panoramic radiographs. Fisher-Brandies et al,[21] in their study, reported a difference of 2.2–3.6 degrees in the gonial angle between panoramic and lateral cephalogram and the difference was statistically significant. It is possible to suggest that using panoramic radiography for measuring the gonial angle should be cautiously considered and that cephalometric analysis serves as the gold standard tool when measuring the gonial angle especially for critical decisions with orthodontics treatment or surgical planning and for forensic purposes requiring comprehensive analysis. Although panoramic radiographs are occasionally a preferred option for measuring gonial angles since they allow clear and independent viewing of the right and left gonial angles, the accuracy of the measurements should always be prioritized.

In the current study, gender had irrelevant influence on gonial angle range. In addition, when gonial angle measurements were compared between the lateral cephalograms and panoramic radiographs among different malocclusions, differences were nonsignificant. However, comparing the values among different mandibular divergence groups, statistically significant differences were reported for the panoramic radiographs' measurements. The difference could possibly be due to using different anatomical landmarks and points to perform the analysis. In addition, according to a recent report,[22] there are several concerns related to the precision of measuring the FMA automatically using AI-based tools such as the WebCeph platform used in the current study. Previous investigations had confirmed the nonagreement in FMA measurements between manual and digital tracing.[23,24] In addition, several studies have found that it was hard to locate some landmarks such as the gonion, porion, menton, gnathion, orbitale, and articulare using these tools.[25,26]

Conclusion

The present study 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 both imaging modalities in measuring the gonial angle and variations in the gonial angles across different mandibular divergence patterns. While cephalometry remains to be the gold standard tool for reliable gonial angle assessment, panoramic radiographs were more accurate in detecting the differences between the divergence groups in the current study.

Disclosure

The authors declare no conflicts of interest in this work.

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