Original Article

Comparison of Gonial Angle and Alveolar Bone Height Changes in Panoramic and Lateral Cephalometry Radiography in Growing Patients

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Abstract

Background: This study aimed to compare the gonial angle and alveolar bone height changes between panoramic and lateral cephalometry radiographic images in class II malocclusion patients before and after orthodontic treatment.

Methods: The obtained radiographic images were selected from among 120 class 2 malocclusion cases. The gonial angle and alveolar bone height were measured in the midline and molar regions of panoramic and lateral cephalometric radiographs using the software tools before and after the treatment of patients. Study data were analyzed by SPSS statistical software (version 21.0), and a significance level was set to 0.05 for all statistical tests.

Results: Based on the results, no significant difference was found regarding the gonial angle before and after treatment on the right and left sides in panoramic radiography and the gonial angle changes before and after treatment in cephalometric radiography ($P > 0.05$). However, the obtained results for posterior and anterior alveolar ridge height were significant in panoramic and cephalometric radiographs ($P < 0.05$). Moreover, the comparison of the measured gonial angle values before treatment in panoramic and cephalometric radiography represented a significant level ($P < 0.05$). Eventually, the statistical results suggested that the alveolar bone height differences between panoramic and cephalometry radiography were significantly different in both anterior and posterior regions after treatment ($P < 0.05$).

Conclusions: The findings indicated that only measurements obtained from the panoramic radiography were valid for the gonial angle. However, panoramic and cephalometry radiography procedures cannot be replaced for assessing the anterior and posterior alveolar bone height.

Keywords: Cephalometric radiography, Panoramic radiography, Gonial angle, Alveolar bone height

Background

Correct diagnosis and treatment planning in orthodontics depend on the obtained data from diagnostic aids such as clinical examinations, study models, and relevant radiography imaging procedures. Lateral cephalometry and panoramic radiography are essential tools in treatment planning and are commonly recommended for orthodontic patients (1-3).

Panoramic radiography is typically performed in orthodontic treatments in order to evaluate the patient jaws and teeth. Orthodontists mostly use the mentioned imaging procedure to study the teeth (number and shape), the presence of impacted teeth, the rate of root resorption, ankylosis, teeth maturity level, condylar shape, sinus evaluation, temporomandibular joint, fractures, cysts, and tumors, as well as to assess the alveolar bone plane and periodontal tissues. Therefore, this imaging modality has been applied as an important screening tool in orthodontics (4-6). The gonial angle is an indicator for traditional evaluation during orthodontic treatment. The angle represents the mandibular plane steepness and can be used to predict the mandibular growth pattern (7,8).

In cephalometric radiographs, although superimposition can reduce the precision of measurement in gonial angle, it does not happen in panoramic radiography, resulting in an increasing trend regarding the use of this radiography in jaw evaluations. Moreover, panoramic imaging can be performed in a little time at a low associated radiation dose with high availability of panoramic imaging devices relative to cephalometry equipment, making the patient and the dentist consider these advantages and choose cost-effective panoramic radiography instead of lateral cephalometric radiography as a critical component in the patient orthodontic record (9-12). The present study aimed to evaluate the gonial angle and alveolar bone height changes in both panoramic and lateral cephalometric radiographs taken from patients of growing age before and after orthodontic treatment and compare these changes in the mentioned imaging techniques.

Materials and Methods

This cross-sectional study was registered in the Research Council of Hamadan University of Medical Sciences. The obtained radiographic images from 120 class 2 malocclusion cases were evaluated based on the study purpose.

The selected images were entered into the computer using Cliniview imaging software (version 10.2.6, KaVo Company), and the considered measurements were taken by the software tools.

The availability sampling methodology was performed and samples were selected from the recorded images in the School of Dentistry of Hamadan University of Medical Sciences according to the inclusion criteria.

The inclusion criteria included children of growing ages (8-13 years old) under previous orthodontic treatment, available panoramic and lateral cephalometric radiographs with acceptable quality before and after orthodontic treatment, and class 2 malocclusion cases.

On the other hand, the exclusion criteria were blurred radiographs, craniofacial malformations, and severe skeletal discrepancy.

For every patient, the height of the gonial angle and alveolar bone in the midline and molar area was measured on panoramic and lateral cephalometric radiographs before and after treatment according to some procedures.

Panoramic and lateral cephalometric images taken from all chosen patients before and after treatment were entered into the Cliniview imaging software (version 10.2.6, KaVo Company), and the measurements were obtained using the software tools including the ruler and a conveyor. The gonial angle was measured in lateral cephalometric radiography imaging based on articular-gonion-menton points (3).

Articular point: A junction of the lower cranial surface and the posterior condylar surface

Gonion point: A junction of ramus and the mandibular plane

Menton point: The lowest point of the mandibular

symphysis in the midsagittal plane

The posterior plane of the ramus (or line tangent to the condylar border and the posterior border of the ramus) and the lower mandibular plane (tangent line to the lower mandibular border) were plotted to measure the gonial angle using panoramic radiography on both sides, and then and their point of intersection was considered as the gonial angle (3). The gonial angle values on the right and left sides were measured separately.

Additionally, the vertical dimension from the alveolar ridge in the distal mandibular first molar to the lower border and the dimension from the midline alveolar crest to the lower border were measured for estimating the alveolar bone height in panoramic radiography (13). In addition, the dimension from the highest point of the alveolar ridge to the lower mandibular border in both anterior mandibular and molar regions was taken to measure the alveolar bone height in cephalometric radiography (14).

The measurements were performed by a dental student with the necessary training and then repeated for 20% of the samples by a maxillofacial radiologist. If there was an acceptable agreement, the obtained dimensions by the first observer were evaluated, otherwise, the measurements were repeated for the second time.

Likewise, the time interval between the two taken radiographs was 18-33 months and was considered as a co-variate in the statistical analysis.

Study data were collected and analyzed by SPSS 21.0 statistical software using descriptive statistics and statistical tests including the paired t test. A significance level was set to 0.05 for all performed statistical tests.

Results

In this study, panoramic and lateral cephalometric images from 120 patients (including 47 and 73 males and females, respectively) were used, and the mean age of patients was 10.8 ± 1.97. Table 1 presents the inter- and intra-observer agreement for the measured dimensions. Further, Table 2 provides the mean dimensions of the left and right gonial angles before and after the orthodontic treatment of patients in panoramic and lateral cephalometric radiographs.

Furthermore, the mean dimensions from the posterior and anterior alveolar bone height before and after orthodontic treatment in panoramic and cephalometric radiographs are listed in Table 3.

Similarly, Table 4 summarizes the changes of gonial angle and the alveolar bone height in both posterior and anterior regions before and after treatment using

Table 1. Intra-class Correlation Coefficient Used for the Evaluation of Reliability in the Inter- and Intra-observer Agreement

Intra-observer agreement	1st observer	0.962 ($P<0.001$)
	2nd observer	0.971 ($P<0.001$)
Inter-observer agreement		0.997 ($P<0.001$)

Table 2. Mean Left and Right Gonial Angle Before and After the Treatment of Patients Using Panoramic Radiography and Cephalometry

Variables	Mean ± SD
The gonial angle on left side before treatment in panoramic images (PGBL)	126.40 ± 4.42
The gonial angle on left side after treatment in panoramic images (PGAL)	126.12 ± 6.49
The gonial angle on right side before treatment in panoramic images (PGBR)	124.42 ± 4.80
The gonial angle on right side after treatment in panoramic images (PGAR)	124.28 ± 6.49
The gonial angle before treatment in lateral cephalometric images (CGB)	124.33 ± 4.43
The gonial angle after treatment in lateral cephalometric images (CGA)	124.68 ± 5.53

Note. SD: Standard deviation.

Table 3. Mean Alveolar Bone Height in Both Posterior and Anterior regions Before and After Treatment Using Panoramic and Cephalometric Radiographic Images

Variables	Mean ± SD
The anterior alveolar bone height before treatment in panoramic images (PHBA)	29.06 ± 2.25
The anterior alveolar bone height after treatment in panoramic images (PHAA)	29.35 ± 1.70
The posterior alveolar bone height before treatment in panoramic images (PHBP)	22.27 ± 1.43
The posterior alveolar bone height after treatment in panoramic images (PHAP)	23.46 ± 2.22
The anterior alveolar bone height before treatment in lateral cephalometric images (CHBA)	28.86 ± 1.98
The anterior alveolar bone height after treatment in lateral cephalometric images (CHAA)	29.77 ± 1.80
The posterior alveolar bone height before treatment in lateral cephalometric images (CHBP)	22.20 ± 2.02
The posterior alveolar bone height after treatment in lateral cephalometric images (CHAP)	22.82 ± 1.25

Note. SD: Standard deviation.

panoramic and cephalometric radiographs. According to the analysis, there were no significant differences between the obtained dimensions from the gonial angle before and after treatment on the right and left sides using panoramic radiography imaging, as well as the gonial angle changes before and after treatment using cephalometric radiography imaging ($P > 0.05$). However, the obtained results from posterior and anterior alveolar ridge height in panoramic and cephalometric radiographic images were significantly different ($P < 0.05$).

Based on data in Table 5, the statistical t-test was applied to compare the dimension of the gonial angle before and after treatment using panoramic and cephalometry radiographic images. The test results showed that the comparison of the measured dimension of the gonial angle before treatment was significant in panoramic and cephalometric radiography imaging ($P < 0.05$). Conversely, the comparison was not significant for those after treatment in panoramic and cephalometric radiography imaging ($P > 0.05$).

In this study, the statistical t-test was employed to compare changes in posterior and anterior alveolar bone height using panoramic and cephalometric radiographic imaging. According to the findings (Table 6), the dimension of the anterior and posterior alveolar bone height significantly differed after treatment in panoramic and cephalometric radiographs ($P < 0.05$). Contrarily, the statistical comparative results of the anterior and posterior alveolar bone height represented no significant difference before treatment using panoramic and cephalometry radiography imaging ($P > 0.05$).

The analysis of covariance was performed based on the repeated measures to compare differences in alveolar bone height variables before and after treatment according to the time interval between two radiographs (18-33 months) and was considered as a co-variate. The results suggested that radiographic differences of alveolar bone height in both posterior and anterior regions before and after treatment were significant in cephalometric and panoramic radiographs. Nonetheless, the studied time did not generally have a significant influence on the observed difference between the first and second radiographs (Table 7). Based on the data, a positive correlation was observed between the interval time, and the difference level before and after treatment demonstrated that longer time led to a greater difference before and after the treatment.

Discussion

Lateral cephalometric radiography generally provides beneficial clinical data about the maxillofacial region, but the overlapped right and left facial sides make challenges for taking some measurements in this image (2).

Panoramic radiography produces the entire image of patient bones and teeth, though the obtained image has inherent defects, especially in the anterior region of the jaws, and horizontal and vertical distortions. The panoramic image is constructed based on a unique method; therefore, horizontal distortions are more critical than vertical types. On the other hand, lateral cephalometric radiography cannot produce the same data provided by a panoramic view. Thus, although there are some distortions in the panoramic images, the mentioned radiographical procedure remained as one of the most common imaging methods among extraoral imaging techniques (12).

The gonial angle symbolized the overall mandibular shape. This angle may play an essential role in predicting growth and has substantial implications on the initial growth rate, facial profile changes, and positioning of the mandibular anterior teeth. Orthodontists should prescribe both panoramic and lateral cephalometric radiography procedures in order to evaluate the anterior and posterior facial height changes and judge the efficiency of the applied orthodontic appliances during therapy.

Chalipa et al compared lateral cephalometric radiographs with panoramic images to measure the gonial angle in class II malocclusion cases. They measured the gonial angle in panoramic and lateral cephalometric radiographs from 281 boy and girl patients aged 10.9 years old (mean). The

Table 4. Comparison of the Dimension Taken for the Gonial Angle and Alveolar Height in Both Posterior and Anterior Regions Before and After Treatment Using Panoramic and Cephalometric Radiographic Images

Variables	Mean Difference±SD	P Value
The gonial angle difference on left side before and after treatment in panoramic images (PGBL-PGAL)	0.44±0.28	0.531
The gonial angle difference on right side before and after treatment in panoramic images (PGBR-PGAR)	0.47±0.13	0.779
The gonial angle difference before and after treatment in lateral cephalometric images (CGB-CGA)	-0.34±0.33	0.301
The difference of anterior alveolar bone height before and after treatment in panoramic images (PHBA-PHAA)	-0.29±0.13	0.032
The difference of posterior alveolar bone height before and after treatment in panoramic images (PHBP-PHAP)	-1.19±0.16	0.000
The difference of anterior alveolar bone height before and after treatment in lateral cephalometric images (CHBA-CHAA)	-0.91±0.16	0.000
The difference of posterior alveolar bone height before and after treatment in lateral cephalometric images (CHBP-CHAP)	-0.62±0.18	0.001

Table 5. Comparison of Dimensions Taken for the Gonial Angle Before and After Treatment Using Panoramic and Cephalometric Radiograph Images

Variables	Mean±SD	P Value[a]
Mean gonial angle before treatment in panoramic images (average PGB)	125.41±4.26	
Mean gonial angle before treatment in lateral cephalometric images (CGB)	124.33±4.43	
The compared mean gonial angle before treatment in panoramic and lateral cephalometric images (average PGB-CGB)	1.08±0.23	0.000
Mean gonial angle after treatment in panoramic images (average PGA)	125.20±6.12	
Mean gonial angle after treatment in lateral cephalometric images (CGA)	124.68±5.53	
The compared mean gonial angle after treatment in panoramic and lateral cephalometric images (average PGA-CGA)	0.52±0.32	0.103

Note. SD: Standard deviation.
[a] *t* test.

Table 6. Comparison of the Alveolar Bone Height Changes in Both Posterior and Anterior Regions Using Panoramic and Cephalometric Radiographs

Variables	Mean Difference±SD	P Value[a]
The difference of anterior alveolar bone height before treatment in panoramic and lateral cephalometric images (PHBA-CHBA)	0.12±0.20	0.116
The difference of anterior alveolar bone height after treatment in panoramic and lateral cephalometric images (PHAA-CHAA)	-0.42±0.09	0.000
The difference of posterior alveolar bone height before treatment in panoramic and lateral cephalometric images (PHBA-CHBA)	0.06±0.10	0.517
The difference of posterior alveolar bone height after treatment in panoramic and lateral cephalometric images (PHAP-CHAP)	0.16±0.64	0.000

Note. SD: Standard deviation.

Table 7. Comparison of the Alveolar Bone Height Difference Before and After Treatment in Both Anterior and Posterior Regions Using Panoramic and Cephalometric Images Based on the Co-variate Time Interval

Variables	ANOVA Results		Correlation of Differences Before and After Treatment With Time Interval (Correlation)	Correlation (P Value)
	Differences Before and After Treatment (P Value)	Time Interval Between Two Radiographical Images (P Value)		
The posterior alveolar bone height in panoramic images (PHP)	<0.001	0.172	0.517	<0.001
The anterior alveolar bone height in panoramic images (PHA)	<0.001	0.008	0.757	<0.001
The posterior alveolar bone height in lateral cephalometric images (CPHP)	<0.001	0.161	0.660	<0.001
The anterior alveolar bone height in lateral cephalometric images (CHA)	<0.001	0.067	0.633	<0.001

Note. ANOVA: Analysis of variance.

obtained results revealed no significant difference between the taken angles in these radiographs, and there was no significant difference between the left and right gonial angles in each patient (2).

In the present study, the gonial angle was calculated according to the mentioned landmarks in both lateral cephalometric and panoramic radiographs for the mixed dentition age group, and then the obtained results were compared with each other.

In our study, the alveolar bone height in panoramic radiographs was obtained based on the vertical dimension between the alveolar ridge in the first mandibular molar and the lower border and between the midline alveolar crest and the lower border. Tang et al also applied this procedure (13).

Additionally, the dimension between the most inferior points of the alveolar ridge in the anterior mandible and the lower mandibular border of the molar region was measured to compute the alveolar bone height in cephalometric radiographs.

Tang et al conducted a comparative study with panoramic digital radiography and the cone-beam computed tomography (CBCT) procedure for alveolar bone measurements. The CBCT imaging procedure and panoramic radiographs were performed for 86 patients with the future implant surgery. In the posterior region, the vertical dimensions between the maxillary first molar alveolar crest and the maxillary sinus floor, as well as the vertical dimensions between the mandibular first molar alveolar crest and above the inferior alveolar nerve canal were taken, and then the dimension of the maxillary incisor alveolar crest and the nasal floor was calculated in the anterior region.

This study compared the alveolar bone height in the anterior and posterior maxillary and mandibular regions between panoramic radiographs and CBCT images, and according to the obtained results, the measurements in both imaging procedures were not statistically significant.

In the current study, the alveolar bone height in both anterior and posterior regions was compared between panoramic and lateral cephalometric radiographs. The results revealed that these measurements differed in the two taken radiographs.

Nohadani and Ruf studied the vertical facial height and dentoalveolar changes in panoramic radiographs and compared them with the values in lateral cephalometric radiographs. This study sought to evaluate the validity of measuring these parameters using panoramic radiography. Evidence suggested that most parameters have higher measurements in panoramic compared to cephalometry procedures. The correlation between the two radiographs was lowest in the maxillary base angle while the highest in the gonial angle. The results indicated that most parameters have higher measurements in panoramic in comparison to cephalometry radiographs. Accordingly, the panoramic procedure cannot be individually considered for studying longitudinal vertical facial and dentoalveolar changes (15).

However, the measurements in the mentioned study were different from the measured criteria in our study; therefore, it is impossible to compare these results.

In the present study, the results of statistical analysis represented that the mean values of the gonial angle were 125.41 ± 4.26 and 125.06 ± 6.12 in panoramic radiographs before and after treatment, respectively. In addition, these values were 124.33 ± 4.43 and 124.68 ± 5.53 in cephalometric radiographs before and after treatment, respectively.

In another study, Chalipa et al reported that the mean values of the gonial angle for 281 patients at the mixed dentition follow-up were 127.3 ± 5.6 and 127.2 ± 6.1 in panoramic and lateral cephalometric radiographs, respectively (2).

Although the mean ages in the other cited studies were similar to those in the present work, the observed difference in the results could be explained based on the differences in radiography equipment, the measurement error, and racial differences.

In this study, the mean gonial angle was statistically significant before treatment in comparison between cephalometric and panoramic radiographs. However, the difference is clinically negligible. Moreover, the findings of this study revealed that there is no statistically significant difference between the mean gonial angles after treatment in both cephalometric and panoramic radiography, which is consistent with the results of Fattahi & Babouee (16) and Akcam et al (17).

Fattahi and Babouee studied the precision of panoramic radiographs in order to determine the dimensional measurements and mandibular steepness in relation to lateral cephalometry. The angle measurements were compared with the measured parameter in the panoramic and cephalometric images. Next, the gonial angle was measured in 101 patients aged 16 years old (mean) in panoramic and cephalometric radiographs, and the results showed that the gonial angle is not significantly different in both panoramic and lateral cephalometric radiographs in the first and second study stages (16).

Likewise, Akcam et al evaluated the improvement of clinical adaptability for panoramic radiographs. In this study, different parameters, including the gonial angle for 30 patients, were measured and compared in panoramic and lateral cephalometric radiographs. The results indicated that the angle values in the two types of images were not significantly different (17).

In the present study, the comparison between the right and left gonial angles in panoramic radiographs before and after treatment indicated that the difference level was not statistically significant, which is in line with the compared gonial angle in cephalometric radiographs. In these radiographs, the values did not differ significantly before and after treatment.

The comparative results in this study suggested that the alveolar bone height in the anterior and posterior regions before and after treatment in both panoramic and cephalometry radiographs was significantly different, indicating an increase in both radiographs. Moreover, given the time interval as a co-variate, a positive correlation was observed between time and the difference level before and after treatment, implying that longer time causes a greater difference level before and after treatment.

Conclusions

Although there was a statistically significant difference between the gonial angle values measured from panoramic and lateral cephalometry radiographs before treatment, lateral cephalometry can be replaced with the panoramic procedure in order to reduce the radiographic dose for patients in current studies, because the difference is not clinically significant (nearly 1°). However, the alveolar bone height in the anterior and posterior regions cannot be measured by replacing these radiographs.

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Authors' Contribution
Study conception and design: FY and VM. Acquisition of data and drafting of the manuscript: SB and FY. Analysis and interpretation of data: MF and VM. Critical revision: FY

Conflict of Interest Disclosures
The authors declare that they have no conflict of interests.

Ethical Statement
This study was approved by the Research Council of Hamadan University of Medical Sciences with the ethics code of IR.UMSHA. REC.1399.627.

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