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Digital evaluation and correlation of facial growth patterns assessed on lateral CEPH and orthopantomogram through ONECEPH mobile application

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Abstract

OBJECTIVES: This study aimed to investigate the correlation of gonial angle and three linear measurements on OPG and lateral cephalograms and their effects on the different facial patterns using the OneCeph android app.

METHOD: About 90 pre-treatment digital lateral cephalograms and OPGs of 90 patients were selected and divided into 3 categories, based on their growth patterns. The OPGs and lateral cephalograms were uploaded on the OneCeph android app. After calibrating using One linear measurement i.e. length of extracted premolar for OPG and ruler in radiograph for lateral cephalogram, Gonial angle (Ar- Go-Me), ANS-Me (LAFH), U1-NF, L1-MP were measured. The data were collected, tabulated, and subjected to statistical analysis using the SPSS software (version 20.0). The level of significance was kept at 5%.

RESULTS: Values for parameters were highest in the vertical growth pattern followed by average and horizontal in both cephalogram and OPG. Upon comparison of lateral cephalogram and OPG, no significant difference was observed in gonial angle and a significant difference in LAFH and L1-MP in all three growth patterns with OPG scores greater than cephalometric tracing. The interclass coefficient test indicated almost perfect agreement for the gonial angle between the two methods. A substantial agreement was seen for U1-NF on lateral cephalogram and OPG in the vertical group. Also, a fair agreement in the vertical and horizontal group was observed in Lower anterior mandibular height.

CONCLUSION: Vertical parameters such as gonial angle and maxillary anterior dental height can be accurately determined on an OPG by the OneCeph application.

Keywords:

Cephalogram, mobile application, opg

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Introduction

Vertical analysis and facial growth pattern form an integral part of the orthodontic diagnosis. Several vertical cephalometric parameters, such as Steiner's anterior cranial base to the mandibular plane (SN-GoGn), Down's Frankfort horizontal plane to mandibular plane (FMA), Schwartz's maxillary mandibular plane (MMA), and Jarabak's ratio and facial height ratio, are methods used to assess vertical facial pattern. Mattila *et al*. (1977) showed high correlations for gonial angles, inter jaw-base angle, and anterior and posterior face height.[1,2]

Gonial angle has significance for the diagnosis of craniofacial disorders, the vertical parameters, and the symmetry of the facial skeleton. It depicts the form and shape of the mandible, has a pivotal role in forecasting future mandibular growth,

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and has certain effects on the profile and position of the mandibular anterior teeth.[3] On the lateral cephalogram, the gonial angle is measured by taking the tangent to the posterior border of the ramus and the tangent to the lower border of the mandible. Its accuracy of measurements on lateral cephalograms may be affected by the superimposition of the patient's right and left sides. To measure the gonial angle accurately, orthopantomograms (OPGs) can be used instead as the right and left gonial angles are not superimposed and can be measured individually.[4]

Larheim and Svanaes[5] concluded that vertical measurements on the OPG were reliable, but they did not compare this to measurements on cephalograms. Araki *et al*.[6] studied dry skulls and found that the gonial angles measured on OPGs were slightly smaller than those measured on Lateral Cephalograms. The accuracy of the gonial angle as evaluated on OPG and Lateral cephalograms may also depend on the growth pattern of the patient. A thorough review of the literature did not reveal any studies comparing the gonial angle reproducibility in OPG for different facial types.

Technology in form of devices such as mobile phones has revolutionized every aspect of our life ranging from simple communication to education and medicine. In orthodontics, apps have been developed for patient reminders, cephalometric tracings, model analysis, and for staying in touch with patients in general. For cephalometric tracing, OneCeph is reliable and at par with manual tracing.

Thus, the present study was designed to investigate the correlation of gonial angle and three linear measurements on OPG and lateral cephalograms and their effects on the different facial patterns using the OneCeph android app.

Materials and Method

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, I.T.S – Centre for Dental Studies and Research, Muradnagar, Uttar Pradesh, India. Clearence from institutional ethics committee was obtained on 10th November 2021.

The study was conducted using pre-treatment digital lateral cephalograms and OPGs of 90 patients. Radiographs were taken in the department of oral medicine and radiology using the same devices for all patients in the natural head position. All radiographs were viewed and evaluated, and only high-quality radiographs were included in the study. All radiographs were retrospectively analyzed. The patients undergoing first premolar extractions were included in the study. The exclusion criteria for this study were a history of trauma, surgery, syndromes, and asymmetry related to the face or jaw.

The patients were divided into 3 categories, i.e. horizontal, average, and vertical growth patterns based on their Down's Frankfort horizontal plane to mandibular plane (FMA) each pattern consisting of 30 patients. The FMA of each patient was determined on lateral cephalogram using Dolphin software available in the department.

Cephalometric norms for FMA Facial pattern values

Horizontal <21°

Average 21°–29°

Vertical >29°

The OPGs and lateral cephalograms were uploaded on the OneCeph android app. The software allows free measurement [Figure 1]. One linear measurement i.e. length of extracted premolar was measured and entered in the OneCeph app for calibration of OPG measurements [Figure 2]. For the lateral cephalogram the ruler present in the radiograph itself was used for calibration.

The following parameters were taken into account:
1. Gonial angle (Ar- Go-Me)

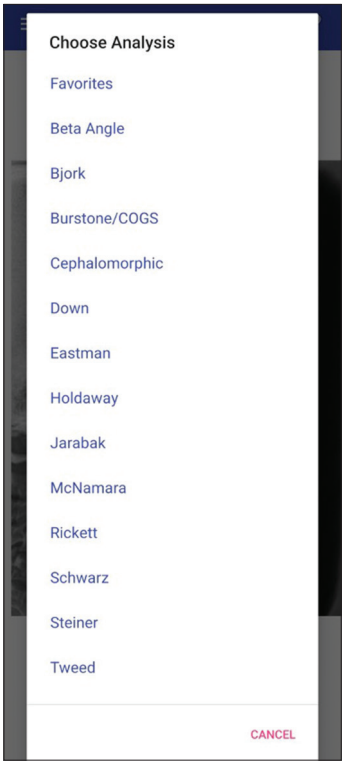

Figure 1: Different Cephalometric analysis available on OneCeph App

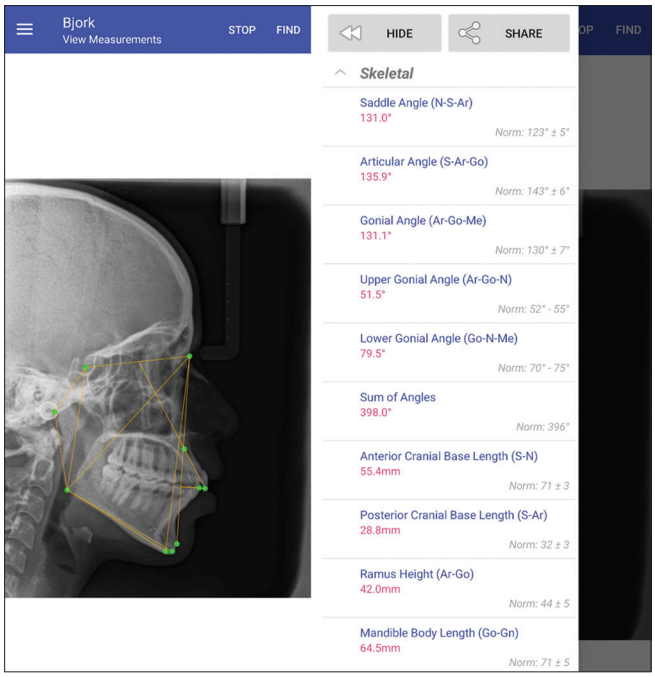

Figure 2: Lateral cephalogram in OneCeph App showing cephalometric readings

2. ANS-Me (LAFH)
3. U1-NF linear measurement)
4. L1-MP (linear measurement)

Gonial angle was determined from Bjork analysis, LAFH from McNamara and U1-PP and L1-MP from burstone/COGS analysis and added to the shortlist [Figure 1]. Anatomic Landmarks required for constructing the tangential lines were first determined using a ruler and then digitized. The software automatically measures the values of these parameters [Figure 3]. On OPG, angle, and measurements only on the right side were considered. The data were collected, tabulated, and subjected to statistical analysis.

Statistical analysis

Pearson correlation coefficient was used for calculating the correlation between cephalogram and OPG which indicates a significant correlation at $P \leq 0.05$. One-way ANOVA test was used for the comparison of Gonial angle, LAFH, U1-NF, and L1-MP traced using cephalometry and OPG among three groups where $P \leq 0.05$ indicated a significant difference. The *post hoc* Tukey test was used for the pairwise comparison of the Gonial angle, LAFH, U1-NF, and L1-MP traced in both types of radiographs. An independent *t*-test was used for the comparison of variables between Ceph and OPG in vertical, horizontal, and average growth pattern subjects.

Results

A comparison of vertical parameters traced using a cephalogram showed that values were highest in the vertical growth pattern followed by the average growth pattern and least in the horizontal growth pattern. The difference in the parameters between the three groups for all parameters was significant. Similar results were observed in OPG besides U1-NF wherein the value was highest in the vertical growth pattern (28.43 ± 4.98 mm) followed by the horizontal growth pattern (28.26 ± 4.40 mm) and least in the average growth pattern (27.95 ± 3.99 mm) and difference in U1-NF between three groups was non-significant [Table 1].

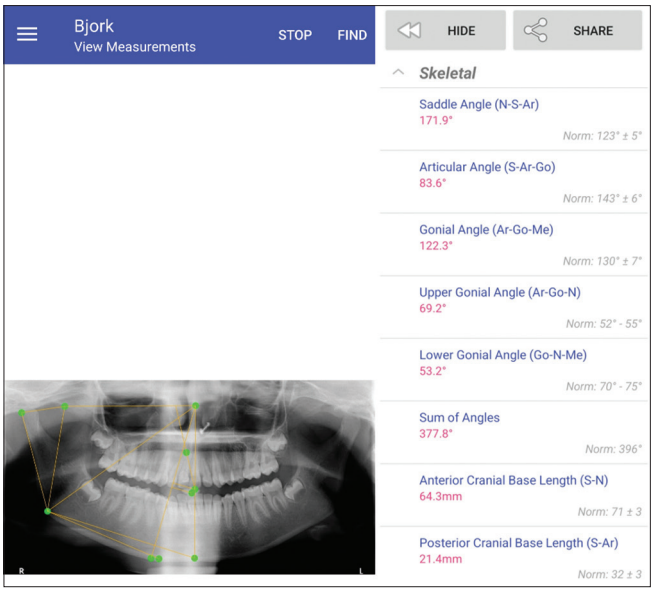

Figure 3: OPG on OneCeph App with landmarks and measurements

Pairwise comparison showed that there was a significant difference between all pairs of growth patterns for gonial angle, LAFH, and L1-MP measurements traced using a cephalogram. However, for U1-NF measurements, the pairwise comparison revealed a significant difference between vertical and horizontal patterns, and between horizontal and average patterns [Table 1].

Pairwise comparison for vertical measurements in OPG revealed a significant difference between vertical and horizontal patterns and between horizontal and average patterns for gonial angle measurements. For LAFH significant difference was observed only between vertical and horizontal patterns for LAFH measurements traced using OPG [Table 2].

There was no significant difference between any of the pairs for U1-NF and L1-MP measurements traced using OPG.

When comparing differences between Cephalogram and OPG, there was no significant difference in U1-NF in vertical growth pattern and gonial angle measurements measurement in all three growth patterns. There was a

Table 1: Comparison of Gonial angle, LAFH, U1-NF, and L1-MPtraced using OPG among three groups

Variable	Group	Mean SD	95% CI		*P*	Significant Pairwise comparison between growth patterns
			Lower	Upper		
Gonial angle	Vertical	125.64±5.90	123.44	127.84	0.001*	H
	Horizontal	112.86±5.46	110.82	114.90		A, V
	Average	122.76±4.72	121.00	124.52		H
LAFH	Vertical	72.77±9.96	69.05	76.49	0.015*	H
	Horizontal	66.92±7.23	64.22	69.62		V
	Average	67.68±7.49	64.88	70.48		
U1-NF	Vertical	28.43±4.98	26.57	30.29	0.917 (NS)	
	Horizontal	28.26±4.40	26.62	29.90		
	Average	27.95±3.99	26.46	29.44		
L1-MP	Vertical	40.39±5.82	38.22	42.57	0.049*	
	Horizontal	37.56±5.23	35.61	39.51		
	Average	37.75±3.34	36.50	39.00		

One-way ANOVA test; *indicates significant difference at $P \leq 0.05$; NS: Non-significant difference

Table 2: Comparison of Gonial angle, LAFH, U1-NF, and L1-MPtraced using cephalometry among three groups

Variable	Group	Mean	95% CI		*P*	Significant Pairwise comparison between growth patterns
			Lower	Upper		
Gonial angle	Vertical	127.61±5.86	125.42	129.80	0.001*	H, A
	Horizontal	115.30±5.83	113.12	117.48		V, A
	Average	123.84±5.53	121.78	125.90		H, V
LAFH	Vertical	62.43±3.65	61.07	63.80	0.001*	H, A
	Horizontal	54.58±4.02	53.08	56.08		V, A
	Average	57.05±3.62	55.69	58.40		H, V
U1-NF	Vertical	26.43±2.21	25.61	27.26	0.001*	H
	Horizontal	23.00±2.67	22.00	24.00		V, A
	Average	25.28±2.77	24.25	26.31		V
L1-MP	Vertical	35.55±2.07	34.77	36.32	0.001*	H, A
	Horizontal	31.21±3.05	30.08	32.35		V, A
	Average	33.20±2.74	32.18	34.22		H, V

One-way ANOVA test; * indicates significant difference at $P \leq 0.05$

significant difference in LAFH measurements and L1-MP in all three growth patterns with OPG scores showing significantly higher values than cephalometric tracing. U1-NF was observed to be statistically significant only for horizontal and average growth patterns [Table 3].

The interclass coefficient test indicated almost perfect agreement between the two methods for measurement of the gonial angle in all three growth patterns and the correlation coefficient also indicated a strong significant correlation between the two methods for measurement of gonial angle which is given by equation $y = 0.9184x + 8.1505$ where x indicates the cephalogram value and y indicates the OPG value [Table 4]. There was a low correlation for LAFH between the two methods, 0.301 for the vertical group, 0.068 for average, and 0.084 for the horizontal group

Also, there was a substantial agreement (0.631) between measurements of U1-NF in the vertical group, poor correlation in the horizontal group (−0.079), and slight between the average group (0.127). Also, a fair agreement in vertical (0.303) and horizontal (0.229), and a slight agreement in average growth pattern (0.010) patients was observed in L1-MP [Table 4].

Discussion

Lateral cephalography and panoramic radiography are important tools for orthodontic treatment planning and are recorded for all such patients. A lateral cephalogram can be used for evaluating the skeletal relationship, growth pattern, dentition, and alveolar process. Panoramic radiography, which is considered the standard of care for dental diagnosis and treatment planning, is used by dentists and orthodontists alike.[7] Some common parameters can be measured on lateral cephalograms and OPG alike. With the advent of technological advancements, mobile applications are now available for performing cephalometric analysis with ease. While desktop cephalometric software has always been available, they have disadvantages as it can only be used on a desktop or a laptop, are expensive and require an internet connection.[8] The purpose of this study was to evaluate and compare the gonial angle, Lower Anterior Facial Height (LAFH), Anterior

Table 3: Comparison of variables between Ceph and OPG

Variable	Group	Method	Mean±SD	Difference	*P*
GONIAL ANGLE	Vertical	Ceph	127.61±5.86	1.97	0.200 (NS)
		OPG	125.64±5.90		
	Horizontal	Ceph	115.30±5.83	2.44	0.100 (NS)
		OPG	112.86±5.46		
	Average	Ceph	123.84±5.53	1.08	0.419 (NS)
		OPG	122.76±4.72		
LAFH	Vertical	Ceph	62.43±3.65	−10.34	0.001*
		OPG	72.77±9.96		
	Horizontal	Ceph	54.58±4.02	−12.34	0.001*
		OPG	66.92±7.23		
	Average	Ceph	57.05±3.62	−10.63	0.001*
		OPG	67.68±7.49		
U1-NF	Vertical	Ceph	26.43±2.21	−1.99	0.052 (NS)
		OPG	28.43±4.98		
	Horizontal	Ceph	23.00±2.67	−5.26	0.001*
		OPG	28.26±4.40		
	Average	Ceph	25.28±2.77	−2.67	0.004*
		OPG	27.95±3.99		
L1-MP	Vertical	Ceph	35.55±2.07	−4.85	0.001*
		OPG	40.39±5.82		
	Horizontal	Ceph	31.21±3.05	−6.35	0.001*
		OPG	37.56±5.23		
	Average	Ceph	33.20±2.74	−4.55	0.001*
		OPG	37.75±3.34		

Independent *t* test; * indicates significant difference at $P \leq 0.05$;
NS: Non-significant difference

Table 4: Measurement of agreement between two methods among different growth patterns

Variable	Vertical	Horizontal	Average
Gonial angle	0.889	0.857	0.945
LAFH	0.301	0.068	0.084
U1-NF	0.631	−0.079	0.127
L1-MP	0.303	0.229	0.010

Intraclass correlation coefficient (ICC) test; −ve sign indicates a negative correlation

Maxillary and mandibular Dental heights on lateral cephalograms and OPG using the OneCeph android app and assess the accuracy, reliability, and effects of different facial patterns on these parameters. The accuracy of the Oneceph application has been assessed by Mohan *et al*.[8] who evaluated the accuracy and reliability of linear and angular measurements obtained from OneCeph digital cephalometric tracing and manual tracings in lateral cephalometry.

The Gonial angle is measured at the point of intersection between the mandibular plane and ramal plane. While landmark points can be easily identified on lateral cephalogram but not OPG,[2] the lines tangential to the mandibular lower border and posterior border of the ramus and condyle can be easily identified on both radiographs and are, therefore, considered acceptable for comparison of.[4] The gonial angle in the present study ranged from 112.03° to 118.57° in horizontal growers, 124.29° to 130.92° in vertical growers, and 120.77° to 126.91° in average growers. The results of the present study agree with the study conducted by Rubika *et al*.[9] which indicated almost similar readings for the three growth patterns as calculated on the lateral cephalogram. The mean for the gonial angle on OPG was calculated to be 112.86°, 125.64°, and 122.76° for horizontal, vertical, and average growth patterns which is almost similar to that calculated on lateral cephalogram. The difference between the reading of two radiographic methods for gonial angle is statistically insignificant. A Similar conclusion was drawn by Katti *et al*.[3] who stated that panoramic radiography can be used to determine the gonial angle as accurately as the lateral cephalogram.

The interclass coefficient test indicated almost perfect agreement between two methods for measurement of gonial angle in all three growth patterns.

Another study by Alhaija evaluated the potential of panoramic radiographs to measure mandibular inclination and steepness. A high correlation between the measurements taken from both radiographs was found. They concluded that panoramic radiographs are a useful tool for measuring gonial angle, which is an indicator of mandibular steepness and, subsequently, mandibular growth direction. The ability to determine growth direction from the OPG can be useful because the majority of dentists request an OPG for patients during a routine dental examination.[10] This will enable the dental professional to spot vertical growth problems using a mobile App.

Horizontal linear measurements have been excluded from this study because of the unreliability of horizontal variables despite the use of head positioner recording and the same radiographer supports as concluded by Welander,[11] McDavid,[12] and Tronje.[13] They stated that horizontal measurements are unreliable because of the distortion effect influenced by a projection factor and a "motion" factor. The vertical measurements on OPG are considered reliable provided that the patient is correctly positioned in the machine during exposure.[5]

As expected, LAFH on the cephalogram measured 62.43 ± 3.71 mm, 54.58 ± 4.08 mm, and 57.05 ± 3.74 mm for vertical, horizontal, and average growth patterns indicating LAFH increases with increasing Gonial angle. This could be due to the backward rotation of the mandibular corpus. The results are the following study conducted by Knigge *et al*.[14] which suggests that the average hyperdivergent mandible and maxilla compared to hypodivergent configurations are rotated downward and backward, relative to the anterior cranial base. However, there was a significant difference

between cephalometric and OPG measurements for all growth patterns with higher values for OPG. There was a low correlation for LAFH between the two methods. This could be attributed to increased lower anterior facial height due to the placement of the bite stick while recording an orthopantomogram. The increase in height due to the placement of the bite stick depends on the overbite in the patient. This contributed to a very weak correlation for LAFH between the two methods.

Other vertical parameters considered in the study are the anterior maxillary and mandibular dental height. The results of the study indicate anterior maxillary and mandibular dental height increases with an increase in gonial angle and lower anterior facial height on lateral cephalogram. The results agreed with the study by Enoki *et al*.[15] which suggests that for AUDH measurements, significant differences were attributed to the groups with normal and excess lower anterior face height. However, the results obtained on OPG do not coincide with that of lateral cephalogram. Also, there was a substantial agreement between measurements of anterior upper maxillary dental height on lateral cephalogram and OPG in the vertical group, poor correlation in the horizontal group, and slight agreement between the average group. Also, a fair agreement in vertical and horizontal, and a slight agreement in average growth pattern patients was observed in Lower anterior mandibular height. The vertical linear measurements on OPG are affected by the inclination of the incisor teeth and jaws. The vertical growth pattern is accompanied by the downward inclination of the lower jaw and may result in a discrepancy anterior maxillary and mandibular dental heights. The results could also be due to an error in marking the point on radiographs. Another reason can be the varying degrees of distortion and enlargement within the OPGs,[16-18] the higher susceptibility for positioning errors,[16,17,19,20] as well as the difficulty in exactly reproducing an OPG in case of repeated exposure.[5] This result is following the study conducted by N. Nohandani and S. Ruf that concludes dentoalveolar parameters on OPG deliver a moderate approximation of the situation depicted on lateral cephalograms. On the other hand, a change in head inclination while recording an OPG results in blurring, distortion, or enlargement of these areas. The change in head position places these areas outside the imaging plane.[1] Nohandani and Ruf also found a high correlation for gonial angle and weak to moderate correlations for vertical facial and dentoalveolar parameters similar to the present study. OneCeph App indicates good accuracy and reliability for measurement of these parameters on cephalogram as well as OPG which shows it can be used easily in day-to-day clinical practice to determine the growth pattern of an individual and determine the treatment plan accordingly in presence of either of the two radiographs. The App is free of cost and easy to use making it beneficial for the practitioner.

Conclusion

It concludes that

- The value of all four parameters increased from horizontal to average to vertical growth patterns.
- The values of OPG and lateral cephalogram are almost similar for the gonial angle in all growth patterns.
- For anterior maxillary and mandibular dentoalveolar heights, the measurements are moderately similar, especially for the vertical group.
- OneCeph App is a reliable App for measurements on lateral cephalogram as well as OPG for gonial angle.

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Conflicts of interest

There are no conflicts of interest.

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