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Panoramic radiographs for investigating skeletal patterns- A comparative study

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Abstract

Introduction: The most commonly used diagnostic aids in orthodontics are lateral cephalograms and panoramic radiographs (OPG). The OPG forms an indispensible orthodontic screening tool in providing information about the teeth, their root length, axial inclinations, morphology and structure, eruption sequence and spatial relationships [1] which is mostly qualitative in nature. The purpose of this study was to evaluate whether the use of OPG could be extended for evaluating skeletal patterns and dentofacial characteristics which are routinely measured on lateral cephalograms. **Materials and Methods:** A total of 80 subjects were chosen, they were divided into two groups: Group A and Group B. Group A included 40 skeletal Class I, dental Class I adults with age range of 18-27 years. Group B included 40 skeletal ClassII, dental Class II Div 1 children with age range of 10 -15 years. The lateral cephalogram and OPG were taken under standard conditions using skeletal cephalostat and various parameters were measured and compared. **Results and Conclusion:** From this study it was concluded that angular measurements on OPG can be used to predict the corresponding angular measurements from the lateral cephalograms, both for the dental and skeletal parameters but the vertical linear measurements cannot be predicted accurately from OPG. The regression equations obtained from this study showed that the Go-Gn/S-N, ANS-PNS/Go-Me (palatal plane/mandibular plane), and Co-Go/Go-Me parameters could be predicted from OPG within statistically significant levels, and their predictability levels were 20.47%, 31.7%, and 10.88%, respectively for group A and 32.0%.22.08% and 52.36% respectively for group B.

Keywords: Panoramic radiographs, Orthopantomograms, Cephalograms.

INTRODUCTION

Panoramic radiographs form an indispensible tool for orthodontic diagnosis and treatment planning. It was introduced by Professor Yrjo Paatero of the University of Helsinki in 1961. It produces a single image of the facial structures that includes both maxillary and mandibular arches with the temporomandibular joints and their supporting structures. It is usually the technique of choice because of its relatively low radiation exposure, degree of patient comfort and the significant amount of diagnostic information obtained by viewing all the teeth and basal bone in one [2].

OPG is one of the essential diagnostic aids in orthodontics for pre-treatment planning, in post-treatment evaluation of success or failure, for assessing the presence or absence of specific teeth, their root length, their axial inclinations, their morphology and structure, in post-treatment evaluation of success or failure and their eruption sequence and spatial relationships [2].

Levandoski in 1991 was the first to analyse panoramic radiographs since then very few studies have been done on this subject as quantitative measurements are considered not be accurate due to the inherent, infinitively variable magnification present in these radiographs [3].

Lateral cephalograms are routinely being used for the skeletal assessment. As OPG is an essential orthodontic diagnostic aid, it would be clinically beneficial if certain information could be gained from OPG by taking OPG under certain standardisation protocols.

So this study was carried out with the following aims and objectives :

1. To investigate the possibility of enhancing the clinical versatility of the panoramic radiograph which is an indispensable tool for dental diagnosis.
2. To investigate whether OPG can be used in the quantitative assessment of a malocclusion.
3. To test whether angular and vertical measurements of OPG can be used as a substitute for the

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corresponding measurements from the lateral cephalograms.

4. To compare the right and left side measurements on the OPG.
5. To compare the panoramic parameters with their cephalometric correspondents in order to determine whether the radiation dose for the patient may be reduced by taking only a panoramic radiograph instead of a panoramic radiograph and a lateral cephalogram in certain indications.

MATERIALS AND METHODS

Lateral cephalometric and panoramic radiographs were obtained from 80 subjects and they were divided into two groups.

Group A included 40 subjects (20 males, 20 females) with following criteria:

1. Skeletal Class I relationship with ANB from 0-4 degrees.
2. Dental Class I relationship with Class I molar relation, pleasing soft tissue profile.
3. Age range: 18-27 years.
4. Average to horizontal growth pattern, excluding vertical growers.

Group B included 40 subjects (20 males, 20 females) with following criteria:

1. Skeletal Class II relationship with ANB>6 degrees.
2. Dental Class II relationship with full cusp Class II or half cusp Class II molar relation, increased overjet, convex soft tissue profile.
3. Age range: 10-15 years.
4. Average to horizontal growth pattern, excluding vertical growers.

The subjects were selected randomly from the records present in the Department of Orthodontics and Dentofacial Orthopaedics.

Panoramic radiographs were taken under standard conditions using a cephalostat with the clinical Frankfort horizontal plane (FHP) kept parallel to floor, while the midfacial plane was in a vertical position. To eliminate any possible superimposition of the cervical vertebra's image on the teeth, the subjects were required to move a step forward when in the cephalostat. As the bite plate used in the panoramic radiographs altered the occlusion, independent reference planes were set up in the maxilla and the mandible on the panoramic images. FHP was constructed between meatus acusticus externus (Mae) and orbital points, and a reference plane was drawn between the intersection point of the ascending and descending tangents on the mandibular canal (MC) and foramen mentale (FMe) [3].

A single operator performed the tracing on an acetate sheet of paper using a 0.5mm lead pencil in a standardized manner to avoid errors due to inter operator variation. Measurements for panoramic radiographs were made for both the right and left sides. The landmarks and measurements of cephalometric and panoramic radiographs are shown in Figures 1 , 2 and Tables 1, 2.

The following panoramic landmarks were identified: (Table 1)

The following reference planes were drawn:

1. Mae-Or; A line joining the meatus acusticus externus and the orbitale.
2. Condylar plane (Co-MC); A line joining Co and MC points.
3. MC plane (MC-FMe); A line joining FMe and MC points.
4. Corpus line (MC-Me): A line joining the MC point and Me point.
5. Palatal plane: A plane joining ANS and PNS points.

The following angular measurements were determined:

1) FH/ANS: Angle formed between FH plane and a line joining ANS to Mae.
2) OMAND (Co-MC/MC-Me): Angle formed between Co-MC plane and MC-Me plane.
3) FH/UOP (FH/U6-U1): Angle formed between FH plane and maxillary occlusal plane.
4) FH/LOP (FH/L6-L1): Angle between FH plane and mandibular occlusal plane.
5) UOCCL (U6-U1-U6): Angle formed by intersection of right and left maxillary occlusal planes.
6) LOCCL (L1-L1-L6): Angle formed by intersection of right and left mandibular occlusal planes.
7) OCOND (Co-MC/FMe-MC): Angle formed between Co-MC plane and FMe-MC plane.
8) OMID (FH/U1): Angle formed between FH plane and a line joining incisal tip (U1) to Mae.

Linear measurements:

1) U6-Palatal plane: Linear distance from U6 to ANS-PNS plane on both right and left sides.
2) U1-Palatal plane: Linear distance from U1 to ANS-PNS plane.
3) L6-mandibular base: Linear distance from L6 to mandibular base on both right and left sides.
4) L1-mandibular base: Linear distance from L1 to mandibular base.
5) Ramal height: Linear distance from Co to a point marked on the angle of mandible by taking the bisector between tangent to posterior border of ramus and tangent to the lower mandibular border.

The following cephalometric landmarks were identified: (Table 2)

Cephalometric Reference Planes:

After drawing above mentioned landmarks, reference planes were traced which are as follows:

1) Sella (S) to Nasion (N) plane (SN): A plane connecting the points Sella and Nasion.
2) Frankfort Horizontal Plane (FHP): A plane connecting the points Mae point and Orbitale.
3) N-A plane:A line joining the points nasion and point A.
4) N-B plane: A line joining the points nasion and point B.
5) Palatal plane: A line joining points ANS and PNS.
6) L6-L1: A line joining points L6 and L1.
7) U6-U1:A line joining poits U6 and U1.
8) Go- Gn Plane: A plane connecting the points Gonion (Go) and Gnathion (Gn).
9) Mandibular Plane (MP): A plane connecting the points Gonion and Menton.
10) Co-Go plane: A line joining the Co- and Go points.

Angular measurements:

1) ANB: Angle formed by the lines N-A and N-B.
2) SNA: Angle formed by the lines SN and N-A.
3) SNB: Angle formed by the lines SN and N-B.
4) SN/N-ANS: Angle formed by the lines SN and a line joining N and ANS points.
5) Co-Go/Go-Me(condylar inclination angle): Angle formed by mandibular plane and Co-Go plane.
6) ANS-PNS/Go-Me: Angle formed by the palatal plane and the mandibular plane.
7) FH/U1: Angle formed between the FH plane and a line joining the points U1 and Mae.

8) FH/ANS-PNS: Angle formed by the palatal plane and the FH plane.

9) Gonial angle: Angle formed between tangents to the posterior border of the ramus and the inferior border of the mandible.

10) Go-Gn/SN: Angle formed by the Go-Gn plane and the SN plane.

11) FH/U6-U1:Angle formed by the FH plane and a line joining the points U6 and U1.

12) FH/L6-L1: Angle formed by the FH plane and a line joining the points L6 and L1.

Linear measurements:

1) U6-Palatal plane: Linear distance from U6 to ANS-PNS plane on both right and left sides.

2) U1-Palatal plane: Linear distance from U1 to ANS-PNS plane.

3) L6-mandibular base: Linear distance from L6 to ANS-PNS plane.

4) L1-mandibular base: Linear distance from L1 to ANS-PNS plane.

5) Ramal height:Linear distance from Co-Go.

STATISTICAL ANALYSIS

The statistical analysis was carried out with the help of a statistical software and the data was analyzed accordingly.The mean and standard deviation values were calculated for the panoramic radiographs and lateral cephalographs (Tables 3,4,5,6). A paired t test was performed to determine whether there were differences between the left and right measurements on the panoramic radiographs (Table 7,8).

The Student t test was used in the present study to determine whether there was a statistically significant difference between male and female subjects in the parameters measured. A correlation test was performed on right and left sides of the OPG to test the similarity between them (Table 9,10). The correlations between the mean values of the panoramic measurements and their cephalometric correspondents were also obtained (Tables 11,12,13).

Regression equations were set for the significant correlations between panoramic parameters and their cephalometric correspondents. Therefore the significance level, percentage and predictability of cephalometric data could be calculated from panoramic radiographs. An independent 't' test was done to compare the panoramic parameters of group A and group B (Table 14).

RESULTS

The means, standard deviations and p values were calculated for both panoramic and cephalometric parameters of group A and B using Student 't' test. As there was no statistically significant difference between male and female subjects for any of the parameters measured, they were combined and further statistical analysis were done together.

The correlation categories were established as follows:

weak ($r < 0.30$), moderate ($r = 0.30–0.70$), and strong ($r > 0.70$).

The following correlation was found between cephalometric parameters and mean values of panoramic parameters as shown in Table 11,12,13.

The independent 't' test revealed no statistically significant differences between panoramic parameters of group A and group B except for certain parameters as shown in Table 14.

DISCUSSION

OPG is an essential diagnostic investigation during orthodontic diagnosis and treatment planning. It is primarily used for the study of bone pattern, bone and root pathology, root size and shape, presence of supernumerary teeth, TMJ evaluation, right and left symmetry. In addition to these advantages if would be highly beneficious if skeletal parameters can also be assessed using an OPG, an additional radiation exposure to an individual could be avoided.

Even though a number of articles have been published on magnification and image distortion in panoramic radiographs, there are only a few studies evaluating the use of panoramic radiographs in dentoskeletal specifications, and they focus mainly on intercondylar asymmetries and gonial angle measurements [4-7].

Comparison between right and left parameters on OPG:

Only FH/U1 of group A (p=0.013) showed statistically significant difference. U1 is the contact point between the maxillary incisors, as it is a midline structure it gets distorted and located sometimes inaccurately. However, the correlation between FH/U1(R) and FH/U1(L) showed a strong positive correlation (r=0.794).

The right and left measurements parameters on OPG showed strong positive correlations in range of r=0.66 to 0.947 which differs from the results obtained by Ackam [3] *et al* who showed that there was a weak correlation between OCOND(R) and OCOND(L)(r=0.50). This difference could be explained by the small sample size (n=30)in their study and due to some samples having right left asymmetry.

Due to standardisation protocols were set for taking OPG, the vertical linear measurements like U6 to palatal plane, U1 to palatal plane, L6 to mandibular base, L1 to mandibular base, ramal height all showed a moderate positive correlation in the range of r=0.3 to 0.6 for both Group A and Group B which is in agreement with the study by (Xie *et al.*, 1996) [8].

The Co-Go/Go-Me to OMAND (Co-MC/MC-Me) showed a positive correlation which is in accordance with the study by Keijo Matilla [5]. Thus the right and left gonial angles can be easily determined individually from OPG avoiding the superimposed images found on the lateral cephalograms.

the external gonial angle from cephalograms and OPG of both group A and B showed no statistically significant difference.

The mean values of the external gonial angle were as follows:

Group A		Group B	
Cephalometric	Panoramic	Cephalometic	Panoramic
123.525º	121.905º	120.70º	122.565º

The difference was not statistically significant.(p=0.12) and the results are in agreement with Mostafa Shahabi *et al* [2] who compared the external gonial angle in panoramic radiographs and lateral cephalograms.So it can be concluded that OPG can also be used to accurately determine the external gonial angle and in addition it avoids the superimposition of right and left sides as in a lateral cephalogram.

The palatal plane to mandibular plane angle (ceph) showed a weak positive correlation with OCOND (r=0.217 for overall correlation). The prediction value R^2 was found to be 31.70% for group A and 22.08% for

group B. This differs from the results by Ackam *et al* [3] who showed a negative correlation between these two parameters (r=-0.39).

The mandibular plane angle (Go-GN/SN) to OCOND in the OPG showed a weak positive correlation(r=0.256 for overall correlation, r=0.205 for group A, r=0.32 for group B) indicating that as the mandibular plane angle increased OCOND also increased. This differs from the results by Ackam *et al* [3] who showed a negative correlation between these two parameters (r=-0.45).

The Co-Go/Go-Me (ceph)showed a positive correlation(r=0.460 for overall correlation) with OMAND (Co-MC/MC-Me) which is in accordance with results obtained by Ackam [3] *et al.*

The UOCCL(OPG) and FH/U6-U1(ceph) showed a mild positive correlation.

The UOCCL (OPG) and FH/U1(ceph) showed a mild negative correlation.

The LOCCL(OPG) and FH/L6-L1(ceph) a mild positive correlation.

The independent 't' test revealed statistically significant differences between certain pamoramic parameters such as FH/LOP, U6 to palatal plane, U1 to palatal plane, L6 to mandibular base and ramal height of group A and B.

The difference in parameters such as FH/LOP and L6 to mandibular base could be explained by the fact that as the subjects selected in group B were average to horizontal growers with strong pterygomassetric sling which slows or retards the eruption of lower molars, thereby decreasing both the values.

The parameters like U6 to palatal plane and U1 to palatal plane were on a lesser side in group B. This difference could be because of deficient maxillary dentoalveolar height and larger amount of distortion in the upper as compared with the lower part of the film (Samawi and Burke, 1984).

Ramal height was lesser in group B (mean=60.91mm) than in group A (mean=66.38 mm) which could be due to the overall smaller mandibular size of group B.

The majority of the panoramic parameters exhibited larger absolute values tdue to the larger magnification of the panoramic radiographs (13–28 percent) compared with lateral cephalograms (10 per cent = average magnification value of the lateral cephalogram unit). The largest vertical and horizontal distortions on the panoramic radiographs were located at the border of the film and thus in the area of the mandibular ramus and the condyles [9].

Another factor was the fact that OPG and lateral cephalograms were obtained in different jaw positions (cephalogram in habitual occlusion; panoramic radiograph in incisor edge-to-edge position).

In order to establish standard panoramic norms for OPG parameters further studies comparing panoramic parameters with their cephalometric correspondents with a much larger sample size and standardisation of OPG recording procedure has to be carried out.

The prediction of cephalometric parameters from OPG can be done by using following regression equations from statistical analysis:

Go-Gn/S-N = -4.47 (±11.874) +0.237 (± 5.787) OCOND

ANS-PNS/Go-Me (PP/MP) = -18.68 (± 5.846) +0.320 (±5.787) OCOND

Co-Go/Go-Me= −8.78(±6.697) +0.887 (±4.419) OMAND.

CONCLUSION

So the following conclusions can be drawn from this study:

1) Right and left measurements in the OPG can be positively correlated.

2) Angular measurements on OPG can be used to predict the corresponding angular measurements from the lateral cephalograms, both for the dental and skeletal parameters.

3) The vertical linear measurements cannot be predicted accurately from OPG.

4) Though OPG can be used in the quantitative assessment of vertical malocclusion, the predictability percentages has been found to be not so high, therefore the clinician should be quite vigilant when predicting the cephalometric parameters from the OPG.

5) With standard exposure conditions and high image quality, panoramic radiographs can provide information on the dimensions of craniofacial structures; however, they are not reliable enough to give acceptably accurate additional information compared with lateral cephalograms.

6) Panoramic radiographs can serve as an adjunct in diagnosis of skeletal patterns but it cannot totally replace lateral cephalograms.

In order to establish standard panoramic norms for OPG parameters further studies comparing panoramic parameters with their cephalometric correspondents with a much larger sample size and standardisation of OPG recording procedure has to be carried out.

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Conflicts of interest

There are no conflicts of interest.

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Table 1: Panoramic landmarks and their significance

Landmarks	Significance
Or	Lowest point on the inferior rim of the orbit
Mae	Meatus Acusticus Externus :location of external auditory meatus.
Co	Condylion
ANS	Anterior nasal spine:anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
Me	Lowest point on the symphysis shadow of mandible.
FMe	Foramen mentale.
MC	Mandibular canal:perpendicular to lower border of mandibular canal from the upper and lower canal tangents is considered to be a stable infrabony structure.
U6	Distobuccal cusp of upper first molar.
L6	Distobuccal cusp of lower first molar.
U1	Contact point of maxillary incisors.
L1	Contact point of mandibular incisors.
PNS	Intersection of nasal line and pterygomaxillary fissure.

Table 2: Cephalometric landmarks and their significance

Landmarks	Significance
Sella Turcica (Sella)	The point representing the midpoint of the pituitary fossa.
Frontonasal Suture (Nasion)	The most anterior point on the frontonasal suture in the median plane.
Orbit Contour (Orbitale)	The lowest point in the inferior margin of the orbit.
ANS (anterior nasal spine):	The anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening
PNS(posterior nasal spine)	The posterior spine of the palatine bone constituting the hard palate.
A- point	The most posterior midline point in the concavity between the anterior nasal spine and the prosthion
U1	Incisal edge of maxillary incisor.
L1	Incisal edge of mandibular incisor.
U6	Distobuccal tubercule of maxillary first molar.
L6	Distobuccal tubercule of mandibular first molar.
Gnathion (Gn)	A point located by taking the midpoint between the anterior (pogonion) and the inferior(menton) points of the bony chin.
Menton	The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram.
Gonion(Go)	A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
Meatus acusticus externus(Porion)	The superior point of the external auditory meatus.
Condylion (Co)	The most superior point on the head of the condyle.

Table 3: Means, standard deviations and p values calculated for parameters measured from cephalograms of group A using Student t test

PARAMETERS	GENDER	N	Mean	std Deviation	p value	Results
SNA	MALE	20	84.15	3.407	0.348	NS
	FEMALE	20	83.00	4.205		
SNB	MALE	20	80.75	3.432	0.318	NS
	FEMALE	20	79.45	4.605		
ANB	MALE	20	3.40	1.273	0.672	NS
	FEMALE	20	3.60	1.667		
CO-GO/GO-ME	MALE	20	113.60	15.418	0.088	NS
	FEMALE	20	120.00	5.487		
ANS-PNS/GO-ME {PP/MP}	MALE	20	23.25	5.486	0.250	NS
	FEMALE	20	25.40	6.134		
FH/U1	MALE	20	26.70	2.577	0.225	NS
	FEMALE	20	29.05	8.114		
FH/ANS-PNS	MALE	20	3.05	2.502	0.758	NS
	FEMALE	20	2.85	1.424		
Ext Gonial Ang	MALE	20	123.525	5.326	0.097	NS
	FEMALE	20	125.75	9.208		
GO-GN/S-N	MALE	20	25.80	7.046	0.145	NS
	FEMALE	20	28.90	6.112		
FH/U6-U1	MALE	20	8.95	5.549	0.885	NS
	FEMALE	20	8.75	2.633		
FH/L6-L1	MALE	20	7.20	5.502	0.641	NS
	FEMALE	20	6.45	4.559		
U6-PP	MALE	20	23.00	2.224	0.479	NS
	FEMALE	20	24.05	6.177		
L6 – Mdbase	MALE	20	37.35	4.416	0.143	NS
	FEMALE	20	35.30	4.256		
U1 – PP	MALE	20	29.60	2.393	0.201	NS
	FEMALE	20	32.35	9.138		
L1-Mdbase	MALE	20	43.60	7.380	0.380	NS
	FEMALE	20	41.85	4.815		
Ramal Ht	MALE	20	63.65	6.002	0.06	NS
	FEMALE	20	59.15	5.622		
FH/ANS	MALE	20	15.45	1.468	0.054	NS
	FEMALE	20	13.85	2.110		

Table 4: Means, standard deviations and p values calculated for parameters measured from cephalograms of group B using Student t test

PARAMETERS	GENDER	N	Mean	Std. Deviation	p value	Results
SNA	MALE	20	81.95	5.031	0.791	NS
	FEMALE	20	81.60	2.998		
SNB	MALE	20	76.10	4.723	0.412	NS
	FEMALE	20	75.10	2.594		
ANB	MALE	20	5.70	1.525	0.150	NS
	FEMALE	20	6.45	1.701		
CO-GO/GO-ME	MALE	20	117.55	4.673	0.098	NS
	FEMALE	20	121.90	10.473		
ANS-PNS/GO-ME {PP/MP}	MALE	20	27.10	23.821	0.661	NS
	FEMALE	20	24.65	6.923		
FH/U1	MALE	20	28.95	6.219	0.147	NS
	FEMALE	20	34.60	15.896		
FH/ANS-PNS	MALE	20	3.10	2.614	0.245	NS
	FEMALE	20	4.15	2.996		
Ext Gonial Ang	MALE	20	121.50	5.326	0.377	NS
	FEMALE	20	113.90	37.686		
GO-GN/S-N	MALE	20	25.50	5.216	0.298	NS
	FEMALE	20	27.50	6.685		
FH/U6-U1	MALE	20	10.60	5.789	0.849	NS
	FEMALE	20	10.95	5.790		
FH/L6-L1	MALE	20	3.75	4.253	0.935	NS
	FEMALE	20	3.85	3.453		
U6-PP	MALE	20	20.10	3.740	0.433	NS
	FEMALE	20	19.25	3.007		
L6 - MD Base	MALE	20	32.90	3.865	0.234	NS
	FEMALE	20	31.15	5.184		
U1 - PP	MALE	20	29.05	5.042	0.101	NS
	FEMALE	20	26.60	4.122		
L1-Mdbase	MALE	20	42.40	5.679	0.057	NS
	FEMALE	20	39.25	4.399		
Ramal HT	MALE	20	58.00	4.230	0.078	NS
	FEMALE	20	54.75	7.010		
FH/ANS	MALE	20	12.80	2.441	0.620	NS
	FEMALE	20	12.45	1.959		

Table 5: Means and standard deviations calculated for parameters measured from orthopantomograms of group A using Student t test

PARAMETERS	GENDER	N	Mean	Std deviation	P value	Results
FH/ANS	MALE	20	15.78	2.854	0.051	NS
	FEMALE	20	18.68	5.754		
FH/U1	MALE	20	26.35	2.749	0.056	NS
	FEMALE	20	29.13	5.659		
CO-MC/MC-FME [OCOND]	MALE	20	135.63	5.436	0.146	NS
	FEMALE	20	132.95	5.951		
CO-MC/MC-ME [OMAND]	MALE	20	142.43	4.496	0.273	NS
	FEMALE	20	140.88	4.313		
FH/UOP (U6-U1)	MALE	20	8.35	3.175	0.967	NS
	FEMALE	20	8.40	4.349		
FH/LOP (L6-L1)	MALE	20	13.25	5.846	0.612	NS
	FEMALE	20	14.18	5.599		
U6 – PP	MALE	20	26.60	2.634	0.908	NS
	FEMALE	20	26.48	4.041		
L6 - Mdbase	MALE	20	41.13	5.710	0.241	NS
	FEMALE	20	39.23	4.272		
Ramal Ht	MALE	20	67.93	6.850	0.118	NS
	FEMALE	20	64.83	5.319		
U6-U1-U6 (UOCCL)	MALE	20	182.73	12.994	0.176	NS
	FEMALE	20	187.75	9.836		
L6-L1-L6 (LOCCL)	MALE	20	162.66	8.349	0.36	NS
	FEMALE	20	160.60	7.343		
U1-PP	MALE	20	25.40	4.817	0.204	NS
	FEMALE	20	27.80	6.771		
L1-Mdbase	MALE	20	41.50	4.110	0.482	NS
	FEMALE	20	40.60	3.912		
Ext Gonial Angle	MALE	20	120.68	5.141	0.07	NS
	FEMALE	20	125.13	6.106		

Table 6: Means, standard deviations and p values calculated for parameters measured from orthopantomograms of group B using Student T test

PARAMETERS	GENDER	N	Mean	Std. Deviation	P value	Results
FH/ANS	MALE	20	19.63	4.292	0.124	
	FEMALE	20	16.25	8.582		NS
FH/U1	MALE	20	27.48	4.725	0.076	
	FEMALE	20	23.13	9.541		NS
CO-MC/MC-FME [OCOND]	MALE	20	133.53	4.983	0.266	
	FEMALE	20	135.45	5.767		NS
CO-MC/MC-ME [OMAND]	MALE	20	138.15	5.104	0.051	
	FEMALE	20	141.80	6.286		NS
FH/UOP (U6-U1)	MALE	20	8.05	4.642	0.342	
	FEMALE	20	9.80	6.674		NS
FH/LOP (L6-L1)	MALE	20	11.90	5.111	0.380	
	FEMALE	20	10.13	7.330		NS
U6 – PP	MALE	20	21.63	2.025	0.945	
	FEMALE	20	21.55	4.419		NS
L6 - Mdbase	MALE	20	36.85	4.583	0.854	
	FEMALE	20	37.10	3.956		NS
Ramal Ht	MALE	20	61.33	4.237	0.616	
	FEMALE	20	60.50	5.938		NS
U6-U1-U6 (UOCCL)	MALE	20	183.75	11.774	0.754	
	FEMALE	20	182.58	11.721		NS
L6-L1-L6 (LOCCL)	MALE	20	180.80	13.121	0.847	
	FEMALE	20	180.10	9.318		NS
U1-PP	MALE	20	20.40	5.586	0.213	
	FEMALE	20	17.95	6.605		NS
L1-Md Base	MALE	20	40.80	5.095	0.562	
	FEMALE	20	41.65	4.043		NS
Ext Gonial Angle	MALE	20	121.23	5.048	0.156	
	FEMALE	20	123.90	6.547		NS

Table 7: Comparison between right and left side parameters measured from panoramic radiographs of group A using paired 't' test

	PARAMETERS	Mean	N	Std deviation	Mean dif	P value	Results
	FH/ANS {R}	17.73	40	5.109	1.000	0.055	NS
	FH/ANS {L}	16.73	40	4.852			
	FH/U1 {R}	27.60	40	5.108	1.275	0.013	S
	FH/U1 {L1}	26.33	40	5.460			
	CO-MC/MC-FME [OCOND] {R}	134.00	40	6.243	-0.575	0.381	NS
	CO-MC/MC-FME [OCOND] {L}	134.58	40	6.034			
	CO-MC/MC-ME [OMAND] {R}	141.55	40	5.028	-0.200	0.659	NS
	CO-MC/MC-ME [OMAND] {L}	141.75	40	4.223			
	FH/UOP (U6-U1) {R}	8.20	40	4.575	0.725	0.531	NS
	FH/UOP (U6-U1) {L}	8.55	40	3.665			
	FH/LOP (L6-L1) {R}	14.08	40	5.833	-0.225	0.211	NS
	FH/LOP (L6-L1) {L}	13.35	40	6.062			
	U6 - PP {R}	26.43	40	3.471	-0.225	0.446	NS
	U6 - PP {L}	26.65	40	3.512			
	L6 - MD base {R}	40.43	40	6.004	0.500	0.373	NS
	L6 - MD base {L}	39.93	40	4.638			
	Ramal Ht {R}	66.70	40	6.285	0.650	0.068	NS
	Ramal Ht {L}	66.05	40	6.413			
	Ext Gonial Angle {R}	122.18	40	6.365	0.550	0.343	NS
	Ext Gonial Angle {L}	121.63	40	7.034			

Table 8: Comparison between right and left sides of parameters measured from panoramic radiographs of group B using paired 't' test

Parameters		Mean	N	Std deviation	p value	Results
	FH/ANS {R}	17.88	40	6.726	0.739	NS
	FH/ANS {L}	18.00	40	7.285		
	FH/U1 {R}	25.45	40	7.805	0.482	NS
	FH/U1 {L1}	25.15	40	7.924		
	CO-MC/MC-FME [OCOND] {R}	134.95	40	5.556	0.124	NS
	CO-MC/MC-FME [OCOND] {L}	134.03	40	5.877		
	CO-MC/MC-ME [OMAND] {R}	140.15	40	5.964	0.280	NS
	CO-MC/MC-ME [OMAND] {L}	139.80	40	6.098		
	FH/UOP (U6-U1) {R}	8.75	40	5.541	0.505	NS
	FH/UOP (U6-U1) {L}	9.10	40	6.376		
	FH/LOP (L6-L1) {R}	11.35	40	6.391	0.195	NS
	FH/LOP (L6-L1) {L}	10.68	40	6.619		
	U6 - PP {R}	21.60	40	3.448	0.914	NS
	U6 - PP {L}	21.58	40	3.493		
	L6 - MD base {R}	37.03	40	4.271	0.057	NS
	L6 - MD base {L}	37.33	40	4.323		
	Ramal Ht {R}	60.75	40	5.453	0.424	NS
	Ramal Ht {L}	61.08	40	5.071		
	Ext Gonial Angle {R}	123.00	40	6.164	0.144	NS
	Ext Gonial Angle {L}	122.13	40	6.256		

Table 9: Correlation between right and left side parameters measured from panoramic radiographs of group A

NO	PARAMETERS	CORRELATION
1	FH/ANS (R) VS FH/ANS(L)	0.794
2	FH/U1(R) VS FH/U1(L)	0.832
3	OCOND(R)VS OCOND(L)	0.777
4	OMAND(R) VS OMAND(L)	0.824
5	FH/UOP(R) VS FH/UOP(L)	0.660
6	FH/LOP(R) VS FH/LOP(L)	0.817
7	U6-PP(R) VS U6-PP(L)	0.860
8	L6-MDBASE(R) VS L6-MDBASE(L)	0.812
9	RAMAL HT (R) VS RAMAL HT (L)	0.941
10	EXT GONIAL ANG(R) VS EXT GONIAL ANG(L)	0.858

Table 10: Correlation between right and left side parameters measured from panoramic radiographs of group B

NO	PARAMETERS	CORRELATION
1	FH/ANS (R) VS FH/ANS(L)	0.947
2	FH/U1(R) VS FH/U1(L)	0.942
3	OCOND(R)VS OCOND(L)	0.790
4	OMAND(R) VS OMAND(L)	0.944
5	FH/UOP(R) VS FH/UOP(L)	0.857
6	FH/LOP(R) VS FH/LOP(L)	0.877
7	U6-PP(R) VS U6-PP(L)	0.912
8	L6-MDBASE(R) VS L6-MDBASE(L)	0.936
9	RAMAL HT (R) VS RAMAL HT (L)	0.885
10	EXT GONIAL ANG(R) VS EXT GONIAL ANG(L)	0.822

Table 11: Table showing correlation between cephalometric and panoramic parameters of group A

Cephalometric parameter	Corresponding panoramic parameter	R value
ANS-PNS/Go-Me	OCOND	0.317
Co-Go/Go-Me	OCOND	0.396
gonial angle	OCOND	0.433
Co-Go/Go-Me	OMAND	0.33
gonial angle	OMAND	0.418
Co-Go/Go-Me	external gonial angle	0.56
U6-PP	U6-PP	0.418
U1-PP	U1-PP	0.587
L6-mandibular base	L6-mandibular base	0.633
L1-mandibular base	L1-mandibular base	0.454
ramal height	ramal height	0.572

Table 12: Correlation between cephalometric and panoramic parameters of group B

Cephalometric parameter	Corresponding panoramic parameter	R value
FH/U1	FH/U1	-0.436
Go-Gn/SN	OMAND	0.383
gonial angle	OCOND	0.557
L1-mandibular base	L1-mandibular base	0.416
gonial angle	OMAND	0.54
Ramal height	Ramal height	0.4

Table 13: A moderate correlation between cephalometric parameters and mean values of panoramic parameters

Cephalometric parameters	Panoramic parameters	R value
FH/U1	FH/U1	-0.321
Co-Go/Go-Me	OCOND	0.488
gonial angle	OCOND	0.441
Co-Go/Go-Me	OMAND	0.46
Gonial angle	OMAND	0.494
Co-Go/Go-Me	External gonial angle	0.638
U6-PP	U6-PP	0.434
U1-PP	U1-PP	0.511
L6-mandibular base	L6-mandibular base	0.391
L1-mandibular base	L1-mandibular base	0.421
ramal height	ramal height	0.601

Table 14: Independent 't' test showing the comparative analysis between panoramic parameters of group A and group B

Parameters	GROUP	N	Mean	Std. Deviation	p value	Results
FH/ANS	GROUP B	40	17.94	6.912	0.592	NS
	GROUP A	40	17.23	4.718		
FH/U1	GROUP B	40	25.30	7.751	0.091	NS
	GROUP A	40	27.74	4.610		
CO-MC/MC-FME	GROUP B	40	134.49	5.408	0.874	NS
	GROUP A	40	134.29	5.787		
CO-MC/MC-ME	GROUP B	40	139.98	5.946	0.157	NS
	GROUP A	40	141.65	4.419		
FH/UOP (U6-U1)	GROUP B	40	8.93	5.743	0.614	NS
	GROUP A	40	8.38	3.758		
FH/LOP (L6-L1)	GROUP B	40	11.01	6.302	0.047	S
	GROUP A	40	13.71	5.669		
U6 – PP	GROUP B	40	21.59	3.393	<0.0001	S
	GROUP A	40	26.54	3.367		
L6 - Md base	GROUP B	40	37.18	4.305	0.006	S
	GROUP A	40	40.18	5.069		
Ramal Ht	GROUP B	40	60.91	5.109	<0.0001	S
	GROUP A	40	66.38	6.254		
U6-U1-U6 (UOCCL)	GROUP B	40	183.16	11.611	0.427	NS
	GROUP A	40	185.24	11.656		
L6-L1-L6 (LOCCL)	GROUP B	40	180.45	11.239	0.537	NS
	GROUP A	40	182.35	15.772		
U1-PP	GROUP B	40	19.18	6.164	<0.0001	S
	GROUP A	40	26.60	5.926		
L1-Mdbase	GROUP B	40	41.23	4.560	0.855	NS
	GROUP A	40	41.05	3.987		
Ext Gonial Angle	GROUP B	40	122.56	5.927	0.634	NS
	GROUP A	40	121.90	6.458		

Table 15: Differences between following panoramic parameters of Group A and Group B.

Parameters	Group A (mm)	Group B (mm)
FH/LOP	13.71	11.01
U6 to palatal plane	26.54	21.59
U1 to palatal plane	26.60	19.18
L6 to mandibular base	40.18	37.18
ramal height	66.38	60.91