ORIGINAL ARTICLE

GMJ. 2014;3(1):29-38
www.gmj.ir

Received: 05 Dec 2013
Revised: 28 Dec 2013
Accepted: 08 Feb 2014

Panoramic Radiography: A Tool for Evaluation of Orthodontic Patients' Sagittal and Vertical Skeletal Relations

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Abstract

Background: Malocclusion, as a worldwide issue, can cause a lot of problems for patients. Panoramic (PR) and lateral cephalometric (LCR) radiographs are both usually indicated for orthodontic treatments. The aim of this study was to analyze vertical and sagittal parameters of both jaws on PRs and to compare them on LCRs.**Materials and Methods:**In this cross sectional study, 61 samples from all patients referring to the Department of Orthodontics of Shiraz Dental School were selected by simple randomized sampling method, meeting specific inclusion and exclusion criteria. Correlations between variables on PRs and LCRs were assessed.**Results:**Vertical angular variables on PR such as H-line/Lower1-Lower6 and Condylar plane/Corpus line were related to some vertical variables on LCR including Anterior nasal spine(ANS)-Menton(Me), Orbitale-Me, ANS-Posterior nasal spine (PNS)/Gonion (Go)-Me, Frankfort Horizontal (FH)/ANS-PNS, Gonial angle, Go-Gnathion (Gn)/Sella-Nasion and FH/Occlusal plane ($P<0.05$).Sagittal variables of maxilla on PR such as Pterygomaxillare (Pm)-Pm, Pm-Ht, Pm-Ht-Pm, and ANS-Pm were related to sagittal variables of maxilla on LCR including Maxillary length, Sella/Nasion/Point A, Point A/Nasion/Point B ($P<0.05$).**Conclusion:** Our results revealed that PRs can provide information on vertical and sagittal dimensions of both jaws. This may help choosing a proper imaging protocol for the patients.**[GMJ. 2014;3(1):29-38]**

Keywords: Lateral Cephalometric Radiography; Panoramic Radiography; Sagittal Dimension; Vertical Dimension

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Introduction

Approximately one-third of Iranian school children need orthodontic treatment, as ascertained by the Index of Orthodontic Treatment Need (IOTN) [1].Orthodontic treatment need is prevalent in other countries all over the world as well [2-5]. Malocclusions can cause a lot of problems for patients including facial appearance sequel, oral dysfunction, and increased susceptibility to periodontal diseases, carious teeth, and trauma. A panoramic radiograph (PR) with appropriate periapical radiographs are among minimal diagnostic records for any orthodontic patient. A lateral cephalometric radiograph (LCR) is needed for all patients except those with minor treatment needs. Cone-beam computed tomography (CBCT) provides new information that is believed to improve the treatment plan [6]. Defined linear parameters, angles, planes and distances on LCR are used to measure and classify patient's craniofacial morphologic features [7]. PR has some advantages such as broad coverage of teeth and facial bones and lower patient radiation doses. Traumas, lesions, dental or osseous diseases, location of third molars and retained teeth can be assessed on PRs too [8]. These evaluations cannot be done on LCR because of bilateral structures superimposition. Therefore, PR seems to be an essential orthodontic screening tool [9]. PR and LCR can be replaced by CBCT which is an advanced radiographic technique but with significantly higher radiation doses [6-8]. By the way, although radiation doses during dental examinations are relatively low, they account for a great number of radiographs taken [10].

Linear measurements on PRs and their actual dimensions were previously studied on dry mandibles [11-13]. There are also a few studies examining PRs as a means of investigating skeletal patterns and comparing the measurements with lateral cephalometric analysis [9, 10, 14-17]. In the results, vertical measurements defined by specified landmarks on PRs and LCRs had moderate to high correlations. However, the parameters from PRs were less predictable compared to LCRs. To the best of our knowledge in this regard most of the studies have evaluated the mandible, its vertical and angular dimensions and growth pattern. Only in one research the maxilla has been assessed [10]. But evaluation of sagittal relation of the jaws is lacking in all previous studies. Although the usefulness of LCR in evaluation of skeletal relations has been proved, LCR is not used as a screening record for all orthodontic patients [6]. Moreover, CBCT is not used routinely for orthodontic diagnostic purposes, because of its cost and lack of availability in all oral and maxillofacial radiologic centers and also its significant radiation doses. On the other hand, PR is used as a routine screening method in all dental clinics for orthodontic purposes [18]. So, it would be helpful if the PR could determine skeletal relations as a preliminary method.

The purpose of this study was to evaluate the correlation of the parameter measurements in PRs and LCRs. Consequently, we assessed whether the expense and radiation doses for the patient may be decreased by taking only a PR instead of a PR and a LCR in certain indications.

Materials and Methods

In this cross sectional study, 61 samples were selected by simple randomized sampling method. From all patients referring to the Department of Orthodontics of Shiraz Dental School, 61 subjects fulfilling the following inclusion criteria were randomly selected: fully erupted permanent 1st molar and incisors at the time of initial investigation, visible mandibular condyle and inferior border bilaterally on PRs, and available good quality LCRs and PRs from the same radiology center and the same X-ray machine. The exclusion criteria were: disabilities, syndromes, craniofacial anomalies, significant asymmetries, and multiple tooth agenesis [10, 17]. Both radiographs (LCR and PR) of each subject were taken on the same day and taken with the same X-ray machine (Plan MecaPromax, Plan Meca, Helsinki, Finland).

Then the radiographs were manually traced on cephalometric tracing paper (0.003 inch, Japan) and analyzed using comparable reference points, which can be located on the LCR

and the PR. Double contours on the LCR were averaged, while on the PR the landmarks were located separately for the left and right side and the mean was calculated. All registrations were performed twice by one investigator under the supervision of an orthodontist, and the mean value of the duplicate registrations was used in the final evaluation [17]. The landmarks and variables used on LCRs and PRs are defined in table-1 and figures-1 and -2. The relations between vertical angular variables on PR such as H-line/ Lower1-Lower6 and Condylar plane/ Corpus line and some vertical variables on LCR including Anterior nasal spine (ANS)-Menton (Me), Orbitale-Me, ANS-Posterior nasal spine (PNS)/ Gonion (Go)-Me, Frankfort Horizontal (FH)/ ANS-PNS, Gonial angle, Go-Gnathion (Gn)/ Sella-Nasion and FH/ Occlusal plane were evaluated.

Table 1. Landmarks Definition on Panoramic Radiographs and Lateral Cephalometric Radiographs (*Part A*)

Landmarks & planes	Definition
	On PRs
Pm	Pterygomaxillare: the apex of teardrop shaped radiolucency at the initiation of intersection between posterior border of maxilla and lateral Pterygoid plate
Ht [10]	Intersection between the H-lines of the right and left side
Ht'	Intersection between the FH-lines of the right and left side
Go [10]	Gonion:: intersection of a tangent to the posterior border of the ramus through Cod and a tangent through Tgc and Gn
Me	Menton: a point on inferior border of mandible positioned in the same distance from right and left Gn
Mae [6]	Meatus: The most sup. point of external auditory meatus
Or [10]	Orbitale: most inferior point of the orbital wall
Co [10]	Condylion: most superior point of the condyle
Mc [9]	Mandibular canal: perpendicular to lower border of MC from intersection of lower and upper canal tangents
U6	Upper 6: Mesiodistal center of occlusal surface of maxillary 1st molar
U1[9]	Upper 1: Contact point of maxillary incisors
L6	Lower 6: Mesiodistal center of occlusal surface of mandibular 1st molar
L1[9]	Lower 1: Contact point of mandibular incisors
Gn [10]	Gnathion: most inferior point of the bony protuberance of chin on the inf border of mandible, on each side of the midline
ANS[10]	Anterior Nasal Spine: most inferior point in which the nasal borders of the maxillary bones meet in the median sagittal plane
FH [10]	Frankfort Horizontal: Line through Or and Mae
H[10]	H-line: modified Frankfort horizontal: Line through Or and Co
Corpus Line[9]	Line through Mc and Me
Condylar plane[9]	Line through Co and Mc

Table 1. Landmarks Definition on Panoramic Radiographs and Lateral Cephalometric Radiographs (*Part B*)

	On LCRs
A [7]	Point A: The deepest point of anterior border of the maxillary alveolar ridge concavity
B[7]	Point B: The deepest point of anterior border of the mandible
N[7]	Nasion: Frontonasal suture
S[7]	Sella: Center of hypophyseal fossa
PNS[7]	Posterior Nasal Spine: The tip of posterior nasal spine
ANS[7]	Anterior Nasal Spine: The tip of anterior nasal spine
Go[9,10]	Gonion: intersection of a tangent to the posterior border of the ramus through Cod and a tangent through Tgc and Gn
Me[7]	Menton: The most inferior point of symphysis
Gn[7]	Gnathion: Most inferior point of the lower contour of the bony chin
Or[10]	Orbitale: most inferior point of the orbital wall
Co[7]	Condylion: most superior point of the condyle
Pgn[6]	Prognathion: Point on the mandibular symphysis farthest from Condylion
Ar [6]	Articulare: the point of intersection between the shadow of the zygomatic arch and the posterior border of the mandibular ramus
FH[6]	Frankfort Horizontal line: Line through Or and Mae
Occ.P[6]	Occlusal Plane: Line drawn along the maximum intercuspation of posterior teeth
Maxillary length[6]	Co to lower ANS, defined as the point on the lower shadow of the anterior nasal spine where the projecting spine is 3 mm thick.
Mandibular length[6]	Co to Pgn
Gonial angle [6]	Angle between Ar, Go and Me

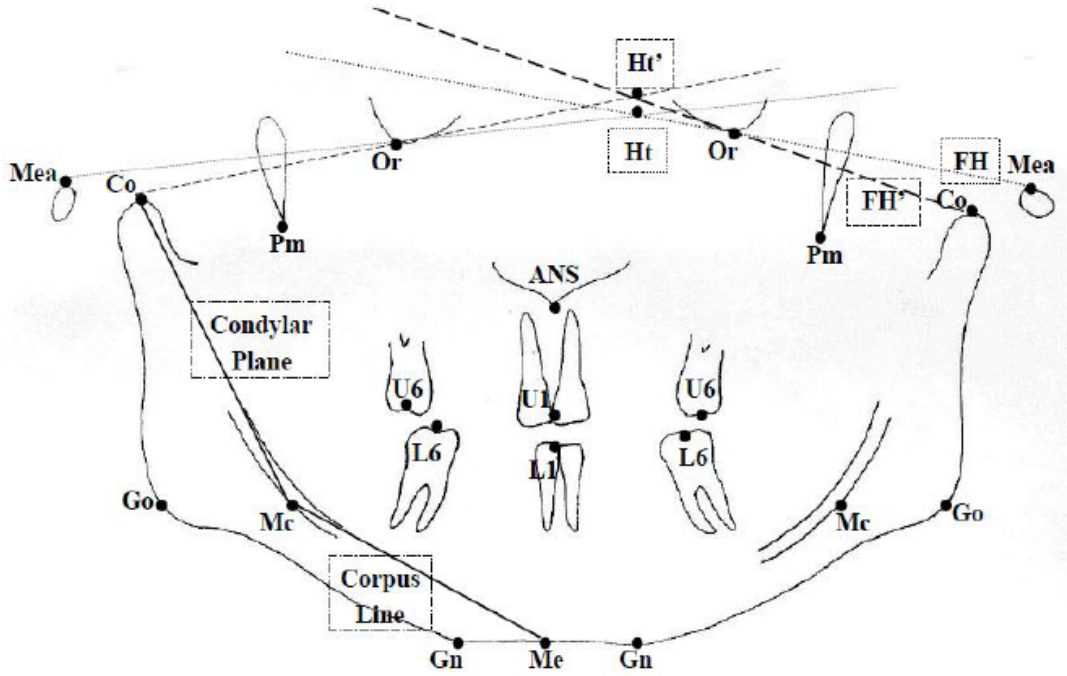

Figure 1. Landmarks on Panoramic Radiographs

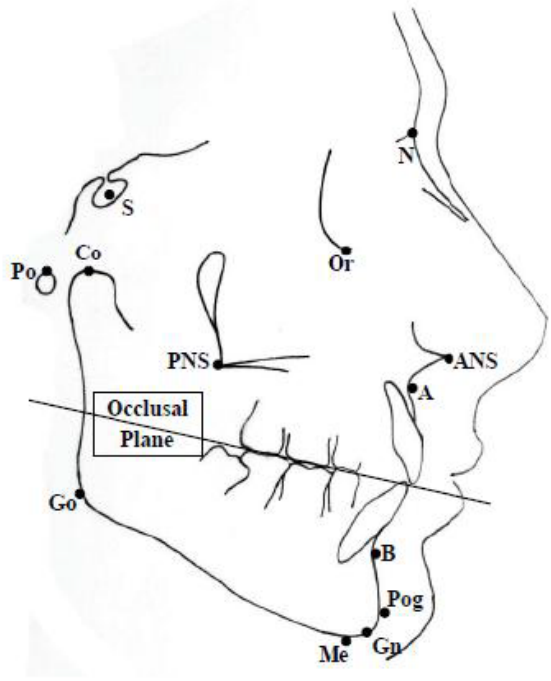

Figure 2. Landmarks on Lateral Cephalometric Radiographs

PR variables were divided into three groups as below:

1. Representative of sagittal relation of maxilla: linear parameters of PM-PM, ANS-PM, PM-Ht and angle of PM/Ht/PM
2. Representative of sagittal relation of mandible: linear parameter of Corpus line and angle of GO/Me/GO
3. Representative of vertical dimension: angles of H/Condylar plane, Condylar plane/Corpus line, H/U6-U1 and H/L6-L1

LCR variables were also categorized into three groups:

1. Representative of sagittal relation of maxilla: linear parameter of maxillary length, angles of SNA, ANB
2. Representative of sagittal relation of mandible: linear parameter of mandibular length, angle of SNB
3. Representative of vertical dimension: linear parameters of ANS-Me, Or-Me, angles of ANS-PNS/Go-Me, FH/ANS-PNS, Gonial angle, Go-Gn/S-N and FH/Occ.P

In cases of existed diastema on PRs, midpoint on the nearest line between the teeth, in the horizontal axis, was assumed as U1 or L1 (12 cases). Regarding U6 or L6 on PRs, if first molars were extracted, fractured or severely destroyed coronally, second molars were used in the same manner as first molars (Five cases). In three cases, right and left H did not intersect on the panoramic frame. Therefore, FH and Ht' were used instead.

On LCRs, ANB angle was considered positive if point A was anterior to the true vertical line drawn from point B and if it was posterior, the angle was mentioned negative. Angles of FH/ANS-PNS and FH/Occ.P were considered positive on LCR if the two lines were divergent to the anterior and they were assumed negative if they were convergent to the anterior.

Irrespective to the degree of Pm/Ht/Pm angle on PR, the inferior angle was always measured. Angles of H/U1-U6 and H/L1-L6 were considered positive on PRs if the two lines were divergent to the midline and vice versa.

Statistical Analysis

Pearson's Correlation test was performed for each panoramic variable in a group with lateral cephalometric variables in the category with the similar name. Regression equation was done for each statistically significant relation. All statistical analysis was executed with SPSS software. (Version 14.0, SPSS Inc, Chicago, IL)

Results

Variables on PR and LCR of 61 samples (51 females and 10 males) were evaluated by Pearson's correlation test.

Vertical variables such as H/Condylar plane and H/Upper6 (U6)-Upper1 (U1) of PR were not related to ANS-Me, Orbitale (Or)-Me, ANS- Posterior nasal spine (PNS) /Go-Me, Frankfort Horizontal (FH)/ANS- PNS, gonial angle, Go-Gnathion(Gn)/Sella-Nasion (S-N) and FH/Occlusal Plane (Occ.P) on LCR ($P > 0.05$). H line (H)/L6-L1 and Condylar plane/Corpus line of PR were directly related to ANS-PNS/Go-Me, FH/ANS-PNS, gonial angle, Go-Gn/S-N and FH/Occ.P on LCR

(P<0.05), but H/Lower6 (L6)-Lower1 (L1) of PR was not related to ANS-Me (P=0.824, r=0.029) and Or-Me (P=0.625, r=-0.064) of LCR in contrast to Condylar plane/Corpus line which is directly related to these two variables on LCRs (P=0.014, 0.045 ; r=0.313, 0.258, respectively)

Regarding sagittal dimension, Pterygomaxillare (Pm)-Pm and anterior nasal spine(ANS)-Pm variable of PR was directly related to maxillary length and Sella/Nasion/Point A (SNA) (P< 0.05) on LCR, but were not related to Point A/Nasion/Point B (ANB) of LCR. (P>0.05) Pm/Ht/PM of PR was inversely related to ANB (P=0.002, r=-0.392) on LCR, but was not related to maxillary length (P=0.699, r=0.051) or SNA (P=0.088, r=0.221). Pm-Ht on PR was directly related to maxillary length (P=0.002, r=0.392) of LCR, but was not related to SNA (P=0.212, r=0.162) or ANB (P=0.291, r=0.137). Corpus line of PR was directly related to mandibular length (P=0.001, r=0.615) on LCR, but was not related to Sella/Nasion/Point B (SNB) (P=0.069, r=0.234) on LCR. Gonion(Go)/Menton(Me)/Go on PR was neither related to mandibular length (P=0.379, r=-0.115) nor SNB (P=0.906, r=-0.015) of LCR.

Table 2. Regression Equations of LCR and PR Variables *(Part A)*

Predicted Cephalometric Parameter	Panoramic Constant	Equation[Predicted Cephalometric Parameter=Constant(±SE)+Coefficient(±SE) Panoramic Constant]	R^2	P-Value	
ANS-PNS/Go-Me	H/L1-L6	ANS-PNS/Go-Me=23.81(±2.20)+0.35(±0.15)H/L1-L6	8.1%	Constant Predictor Regression	0.001 0.026 0.026
Gonial angle	H/L1-L6	Gonial angle=124.25(±1.57)+0.25(±0.11)H/L1-L6	7.9%	Constant Predictor Regression	0.001 0.029 0.029
FH/ANS-PNS	H/L1-L6	FH/ANS-PNS=-1.97(±1.02)+0.16(±0.07)H/L1-L6	7.5%	Constant Predictor Regression	0.059 0.032 0.032
Go-Gn/SN	H/L1-L6	Go-Gn/SN=27.55(±1.33)+0.48(±0.09)H/L1-L6	31.1%	Constant Predictor Regression	0.001 0.001 0.001
FH/Occ.P	H/L1-L6	FH/Occ.P=8.15(±1.42)+0.30(±0.10)H/L1-L6	13.7%	Constant Predictor Regression	0.001 0.003 0.003
Or-Me	Condylar plane/ Corpus line	Or-Me=38.84(±26.64)+0.40(±0.19) Condylar plane/ Corpus line	6.6%	Constant Predictor Regression	0.15 0.045 0.045
ANS-Me	Condylar plane/ Corpus line	ANS-Me=13.10(±23.03)+0.42(±0.17) Condylar plane/ Corpus line	9.8%	Constant Predictor Regression	0.57 0.014 0.014
FH-Occ.p	Condylar plane/ Corpus line	FH-Occ.p=-27.23(±18.37)+0.28(±0.13) Condylar plane/ Corpus line	7.2%	Constant Predictor Regression	0.14 0.037 0.037
Go-Gn/SN	Condylar plane/ Corpus line	Go-Gn/SN=-38.06(±17.63)+0.52(±0.13) Condylar plane/Corpus line	21.9 %	Constant Predictor Regression	0.03 0.001 0.001

Table 2. Regression Equations of LCR and PR Variables *(Part B)*

Predicted Cephalometric Parameter	Panoramic Constant	Equation[Predicted Cephalometric Parameter=Constant(±SE)+Coefficient(±SE) Panoramic Constant]	R^2	P-Value	
Gonial angle	Condylar plane/ Corpus line	Gonial angle=34.65(±16.52)+0.67(±0.12) Condylar plane/Corpus line	34.9%	Constant	0.04
				Predictor	0.001
				Regression	0.001
FH/ANS-PNS	Condylar plane/ Corpus line	FH/ANS-PNS=-27.37(±12.79)+0.20(±0.09) Condylar plane/Corpus line	7.2%	Constant	0.04
				Predictor	0.036
				Regression	0.036
ANS-PNS/Co-Me	Condylar plane/ Corpus line	ANS-PNS/Co-Me=-50.55(±26.69)+0.57(±0.19) Condylar plane/Corpus line	12.9%	Constant	0.063
				Predictor	0.004
				Regression	0.004
Mandibular length	Corpus line	Mandibular length=40.96(±12.56)+0.93(±0.16) Corpus line	37.8%	Constant	0.002
				Predictor	0.001
				Regression	0.001
Maxillary Length	Pm-Ht	Maxillary Length=67.50(±6.24)+0.29(±0.09)Pm-Ht	15.3%	Constant	0.001
				Predictor	0.002
				Regression	0.002
ANB	Pm-Ht-Pm	ANB=17.29(±4.10)-0.09(±0.03)Pm-Ht-Pm	15.4%	Constant	0.001
				Predictor	0.002
				Regression	0.002
SNA	ANS-Pm	SNA=63.48(±6.68)+0.24(±0.10)ANS-Pm	9.3%	Constant	0.001
				Predictor	0.017
				Regression	0.017
Maxillary length	ANS-Pm	Maxillary length=57.09(±6.87)+0.44(±0.10)ANS-Pm	25.5%	Constant	0.001
				Predictor	0.001
				Regression	0.001
SNA	Pm-Pm	SNA=66.3(±6.44)+0.10(±0.05)Pm-Pm	6.7%	Constant	0.001
				Predictor	0.044
				Regression	0.044
Maxillary Length	Pm-Pm	Maxillary Length=60.38(±6.65)+0.20(±0.05)Pm-Pm	22.5%	Constant	0.001
				Predictor	0.001
				Regression	0.001

Regression equations were performed for each couple of variables which was shown to be related by Pearson correlation test (Table-2). Among vertical variables predictability of LCR parameters from PR was considerable for Go-Gn/SN on LCR and Condylar plane/ Corpus line and H/L1-L6 (r^2=21.9%, 31.1%). Possibility of predicting the LCR sagittal parameters from PR variables was higher for parameters of Mandibular length on LCR and Corpus line on PR (r^2=37.8%), Maxillary length on LCR and ANS-Pm and Pm-Pm on PR (r^2=25.5%, 22.5%, respectively).

Discussion

Considering vertical dimension, our results indicated that H/L6-L1 and Condylar plane/ Corpus line of PR was directly related to ANS-PNS/Go-Me, FH/ANS-PNS, Gonial angle, Go-Gn/S-N and FH/Occ.P on LCR. Condylar plane/Corpus line was also directly related to ANS-Me and Or-Me of LCR.H/ U6-U1 and H/Condylar plane on PR were not related to vertical analysis on LCR.

Therefore, it is speculated that H/L6-L1 and Condylar plane/Corpus on PRs can be used

in lieu of ANS-PNS/Go-Me, FH/ANS-PNS, Gonial angle, Go-Gn/S-N and FH/Occ.P on LCRs to assess vertical skeletal relations. Condylar plane/Corpus also can be used instead of ANS-Me and Or-Me of LCR. According to considerable r^2 values, Condylar plane/Corpus line and H/L1-L6 are the suggested variables to assess vertical relation of jaws on PRs.

Regarding sagittal dimension, Pm-Pm and ANS-PM on PR was directly related to maxillary length and SNA on LCR. Pm/Ht/PM of PR was inversely related to ANB on LCR. Pm-Ht on PR was directly related to maxillary length of LCR. Corpus line of PR was directly related to mandibular length on LCR. Go/Me/Go on PR was neither related to mandibular length nor SNB of LCR.

Consequently, it is hypothesized that maxillary length and SNA on LCR can be substituted by Pm-Pm and ANS-PM on PR to evaluate sagittal skeletal relationship. Similarly ANB and mandibular length can be substituted by Pm/Ht/Pm and Corpus line, respectively. Based on r^2 values, it is recommended to use ANS-Pm, Pm-Pm and Corpus line whenever trying to investigate sagittal relation of jaws on PRs.

In several studies gonial angle was measured and compared on LCR versus PR. Chalipa and his coworkers declared that PRs could be used to measure gonial angle interpreting patient's growth pattern [16]. Similar results were obtained by Shahabi and Zangouei-Booshehri [14,17]. Oksayan concluded that PR was as reliable as LCR regarding gonial angle measurements in all Angle's classification [15]. Our study did not contain such comparison. Rather gonial angle was the representative of vertical relations of the jaws. H/L6-L1 and Condylar plane/Corpus line of PR was found directly related to Gonial angle on LCR.

In 2003, defined variables on PRs and LCRs of 30 patients with class II malocclusion (dental or skeletal) were measured and their relation was assessed with Pearson's Correlation test by Ackam [9]. Using regression equations to determine the predictability of LCR measurements from PRs, Go-Gn/SN, ANS-PNS/Go-Me were found able to be predicted by Condylar plane/mental foramen-Mc of PR and Co-Go/Go-Me predicted by Condylar plane/Corpus line variable on PRs. Statistically significant correlations were also determined between FH/U1-U6, FH/L1-L6 on PRs and FH/U1-U6 on LCRs. Our results showed correlation between H/L1-L6 of PR and FH/Occ.P on LCR but H/U1-U6 was not related to FH/Occ.P in our study. H/L1-L6 was directly related to all vertical variables of LCR in our research, which was not found in Ackam's research. The difference may be due to unclear definition of L6 and applying FH instead of H in Ackam's study. We used H (H-line: modified Frankfort horizontal: Line through Or and Co) rather than FH, since Co is more probable to appear on PRs and is easier to be detected compared with Meatus of FH. In contrast to our study, Ackam did not find any relations for the defined sagittal variables. Landmarks were depicted on schematic drawings of tracing but not clearly defined on PRs. Multiple points could be found based on the definition of one landmark point. Among defined variables on PRs were mental foramen and meatus which may not always be visible on PRs.

In 2008, Nohadani and Ruf assessed vertical facial and dentoalveolar changes by comparison between PRs and LCRs of 30 subjects (pretreatment and post treatment radiographs) [10].They used same variables on both LCR and PR and concluded that most variables exhibited larger absolute values on PRs presenting moderate approximation to the situation on LCR. Therefore they did not recommend PRs for analysis of changes in vertical dimension. Definition of Gn on PR was "the most inferior point of the mandible in the canine region of each side" which was affected by tooth condition. In our investigation, Gn was defined as "the most inferior point of the bony protuberance of chin on the inferior border of mandible, on each side of the midline", consequently not affected by tooth condition, and a tooth-related landmark was substituted by a bone-related. Besides, Pm definition on PR was problematic. In our study, a clear definition of "the apex of teardrop shaped radiolucency at the initiation of intersection between posterior border of maxilla and lateral Pterygoid plate" was used.

Since CBCT is not widely used in our country,

we put our focus on PRs which are available in almost all oral and maxillofacial radiographic centers. Every orthodontic patient can afford paying for a PR as a routine screening radiograph. However, we suggest comparing LCR findings with CBCT results in future studies as the new technique will become more prevalent hereafter.

Conclusion

Analysis of vertical and sagittal variables on PRs and LCRs indicated that PRs can provide information on vertical and sagittal dimensions of both jaws in certain conditions of no disabilities, syndromes, craniofacial anomalies, significant asymmetries, and multiple tooth agenesis. However, considering the predictability levels (R^2), clinicians should be careful. By the way, more studies in this regard are still required.

Acknowledgement

The authors thank the Vice-chancellery of Shiraz University of Medical Sciences for supporting this research (Grant # 92-6655). The authors would like to thank Dr. M. Vossoughi from the Dental Research Development Center of Shiraz Dental School and Dr. Gholami from Clinical Research Development Center of Shiraz Namazi Hospital and Dr. A. Alborzi for the statistical analysis. This article was derived from M. Saki's thesis for the degree of Doctoral Dental Surgery.

Conflict of Interest

All authors state that they have no conflict of interest.

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