Comparison of gonial angle measurement on lateral cephalometric and orthopantomogram in different malocclusion groups

Dr. Abdul Jabbar
BDS, FCPS, FFD RCSI, Associate Professor, Department of Orthodontics LUMHS Jamshoro PMDC# 7455-D
Email: Abdul.jabbar@lumhs.edu.pk

Dr. Khuram Saeed
BDS, RDS, MSc Orthodontics, Department of Orthodontics LUMHS Jamshoro PMDC# 18892-D
Corresponding Author email: khuramsaeedkhattak93@gmail.com

Dr. Sana Shah
BDS, RDS, Dental Surgeon at Liaquat University Hospital, Hyderabad.
PMDC# 15320-D
Email: neenoshah@hotmail.com

Dr. Muhammad Siddique Khatri
BDS, RDS, MSc Orthodontics, PDAGD, PDHCHM, Registrar Orthodontic department at LCMD, PMDC# 21725-D
Email: muhammadsiddiquekhatri@gmail.com

Dr. Awais Qarni
BDS, RDS, FCPS Orthodontics trainee AFID Rawalpindi, PMDC# 18907-D
Email: dr.awaisqarni12@gmail.com

Dr. Shazia Shakeel
BDS, RDS ,MSc botany, MA Eng, MBA HRM and MSc orthodontic
Lecturer in BIBI ASEEFA DENTAL College Larkana Chandka Medical College SMBBMU, PMDC# 4093-D
Email: Shaziarehman001@gmail.com

Abstract---Introduction: Growth of the patients occurs in both vertical and horizontal directions. The pattern of the growth can be predicted from both lateral cephalogram and orthopantomogram. GA is one of the important parameter measures from both lateral cephalogram and orthopantomogram which can predict growth direction. In the previous literature GA is measured from LCR and OPG in the vertical

facial growth pattern. The objective of this study is to evaluate the reliability of lateral cephalogram compared to orthopantomogram in determining the value of gonial angle in different types of malocclusion groups (Sagittal skeletal class I, II, III). Material and methods: This was a hospital-based study conducted at the Orthodontic Department, Institute of Dentistry LUMHS, Jamshoro/ Hyderabad, Sindh, Pakistan from 19 October 2020 to 12 April 2021. This study recruited 174 participants of 12 years to 30 years of age, 123 female and 51 male patients. Skeletal class I malocclusion patients are 66, skeletal class II malocclusion patients are 75, and skeletal class III malocclusion patients are 33. Radiographs lateral cephalogram and orthopantomogram were advised to patients and were selected according to the inclusion and exclusion criteria for the accuracy of the results. Results: The mean value of GA in LCR is 123.62º with the range of 107-140.50º and standard deviation of 6.84º, mean gonial angle measured from right side OPG is 121.11º with the range of 105-142.50º and standard deviation of 7.24º while gonial angle from left side OPG is123.81º with range of 107-149º and standard deviation of 7.42º. The mean value of gonial measured from the lateral cephalogram in skeletal class I malocclusion is 123.35º, in skeletal class II malocclusion is 124.15º while the mean gonial angle in skeletal class III malocclusion is 122.96º. According to gender variation the mean gonial angle in female patients from lateral cephalogram is 123.71º while in male patients the mean gonial angle measured from lateral cephalogram is 123.41º. Conclusions: The lateral cephalogram and orthopantomogram both are found reliable in measuring GA. There is no statistically significant difference found in the mean values of gonial angle measurements from lateral cephalograms and orthopantomogram radiographs and so orthopantomogram is also used as alternative for lateral cephalogram for GA measurement. There is no significant difference found in mean GA between skeletal sagittal class I, class II, class III malocclusions. Gonial angle variation in gender and age are found not statistically significant.

Keywords---Gonial angle, Lateral cephalometric radiograph, Orthopantomogram, Different sagittal skeletal malocclusion classes.

Introduction

The basic data records required for orthodontic diagnosis needs expertise in history taking, general observation, clinical examination of the patient , study models analysis [2,63,34], facial and intraoral photographs, radiographs like orthopantomogram and lateral cephalogram and other supplemental diagnostic aids [2,6,7]. For the treatment planning of an orthodontic patients the factors taken into consideration should be the patients chief complaints, gender, age and growth status of the patient from the growth maturity indicators, treatment limitations and treatment objectives.

In 1934 after the emergence of cephalometric, the lateral cephalometric is now most widely used in orthodontic diagnosis for the analysis of configuration of the facial skeleton, relationship of the maxillary and mandibular jaw basis, relationship of the axial inclination of upper and lower incisors teeth, assessment of the soft tissues' morphology, growth pattern and direction, localization of the malocclusion, treatment possibilities and limitations. In 1961 Yrjo Paatero of the University of Helsinki first introduce orthopantomogram and is now used for analysis of dentition [1,13], number and type of teeth present, number and siz of root, caries, Impacted tooth presence, TMJ evaluation, Sinuses, tooth and bone fractures, cyst and tumor presence, alveolar bone levels, face and mandibular normal symmetry and asymmetry. In 1899 after Angle concept of normal occlusion and his malocclusion classification into different groups (Class I, Class II, Class III) the start of the different studies and researches about diagnosing and treatment of the malocclusion occurs [8].

On studying the prevalence of the orthodontic malocclusion both dental and skeletal malocclusion according to WHO is the third most prevalent oral problem after dental caries and periodontal diseases [55]. The malocclusion is most prevalent in sagittal plane than in vertical plane and then in transverse plane [55]. The highest percentage is of class 1 malocclusion in both mixed and permanent dentition. The etiological factors for malocclusion is may be genetically or environmental effect on the dentition, skeletal growth and soft tissue muscles that may alter the normal occlusion.

The five main vertical and horizontal, components of the, face are the cranium and cranial, base, skeletal, mandibular and, maxillary jaw, alveolar process, mandibular and maxillary dentition, the growth pattern and vertical relationship affecting the treatment planning and result of the treatment [10]. Different parameters are taken from radiographs to treat a patient. Gonial angle and Frankfort mandibular plane angle are two of the most important measurement for orthodontic diagnosis, dentofacial orthopedics and orthognathic surgery, and are good indicators for vertical and horizontal growth pattern. The word gonion is derived from Greek word which means angle [24].

Gonial angle and Frankfort mandibular plane angle are taken from both lateral cephalogram and orthopantomogram are mostly used for the evaluation of growth direction pattern. Different studies have done on the measurement of gonial angle and the changes in the values of gonial angle from these radiographs and their reliability. Fisher-Brandies et al. the lateral cephalometric is preferred to determine the gonial angle [13]. Lerheim and Svanaes talk about the accuracy of the gonial angle on lateral cephalometric radiograph is not reliable because of the superimposition of the right and left side angles [29]. This problem of the superimposition can be overcome in orthopantomogram but Akcam et al. found the distortion in the gonial angle from the panoramic radiographic image by the magnification error and displacement [9,11]. Mittila et al. evaluate the same accuracy of gonial angle from both panoramic radiograph and lateral cephalogram[2]. Gonial angle study on lateral cephalogram and panoramic radiograph was also done by Booshehri et al in Iran [12].

Literature review

Orthodontic diagnosis:

Treatment of the dental and skeletal anomalies by orthodontic treatment or by interventional surgery requires special attention to certain conditions [6]. For diagnosing orthodontic patients' certain factors will be taken into consideration which can aid in treatment planning like initial malocclusion, growth status, patient's primary concern i.e. esthetic, treatment limitations and treatment objectives. The diagnosis in orthodontics includes the type of malocclusion either skeletal or dental, class of malocclusion and the severity of malocclusion [71]. The data required for orthodontic diagnosis are derived from routine essential diagnostic aids and also from supplemental diagnostic aids. The essential diagnostic aids are case history, clinical examination, study model analysis, orthodontic photographs and radiographs [71,48], while supplemental diagnostic aids are certain specialized radiographs like orthopantomogram [140,141,18] and lateral cephalogram, maturity indicator, occlusogram. These records are used for the purpose of monitoring facial growth and development of the patient, with or without orthodontic treatment, also use for the research purposes [74]. Ackerman and Proffit recommend a problem-oriented approach to orthodontic diagnosis and treatment planning, which includes identifying the malocclusion and dentofacial deformity, determining the type and cause of the malocclusion, and planning the treatment strategy based on the patient's chief complaint and needs [71]. For the development of orthodontic diagnosis, the clear images of the craniofacial region is important [73]. A systematic investigation of the contribution of these various records in orthodontic patients for the purposes of diagnosing and treatment planning is required, in order to determine and document the contribution of each record to the diagnosing and treatment of individual patients.

Malocclusion:

The intercuspation of the maxillary and mandibular teeth in all mandibular movements and positions [87]. Few experts classify occlusion into physiologic and pathologic categories while most of the experts classify occlusion into normal occlusion, ideal occlusion and malocclusion [87]. The concept of normal cocclusion and malocclusion was first defined by Edward Angle in 1898 [87]. The mesiobuccal cusp of the upper first molar occlude in the buccal groove of the lower first molar and the teeth are arrange in a smooth line [87]. The normal alignment of teeth within the jaw and between the two arches, as well as the normal skeletal relationship between the maxilla and mandible, and the normal muscular and soft tissue relationship. Andrews found six characteristics in orthodontic patients in 1972: molar relationship, accurate crown angulation and inclination, no tooth rotation, tight proximal contact without any space, and a flat curve of spee from 0 to 1.5mm [87]. In 1981 Roth added few extra characteristic to normal occlusion which are the centric occlusion and relationship coincidence, posterior teeth exclusion during protrusion, canine guidance and presence of bilateral tooth contact in centric excursion of tooth [87]. In 1992 Houstan et AL defined normal occlusion is one that cause no functional or aesthetic problems. In 1998 McDonald & Ireland defined ideal occlusion, the correct skeletal bases of the

maxilla and mandible relative to one another and the correct teeth relationship in three planes of space at rest [87].

Growth changes:

Growth changes have high influence on the orthodontic treatment therefore the orthodontist shows high interest in the facial development [92]. Different 2D and 3D radiographs are used to assess the facial growth [92]. There are five functional components of the face in a vertical and horizontal relationship including cranium and cranial base, skeletal maxilla and skeletal mandible, alveolar process and maxillary and mandibular dentitions [18]. With continuous growth of the body in adult life, the maturational changes affect both hard and soft tissues of the face and jaws, also effect on the teeth and supporting structures and the dental occlusion itself. To get data about the growth of these hard tissues of the face, skeletal jaws, soft tissues, neighboring tissues, dentitions and their axial inclination, hard tissues correlation and soft tissue proportions different radiographs is used in orthodontics [18].

Jaw rotation during growth:

With increasing age, during growth, rotation of the jaws occur, usually refers to the mandible but maxilla also shows growth rotation. In the upper face the rotation of the maxillary corpus was also documented [116]. During growth the maxilla and mandible move in the forward and downward direction, the forward translation of the maxilla is less than the mandible but the sagittal relationship of the teeth remains unchanged [109]. Mandibular growth rotations are a reflection of differential growth in the anterior and posterior facial height. Bjork and coworkers in 1955 first technique to study bone growth by placing titanium alloy rods into area of facial bones, the extent to which maxilla and mandible rotates. They take normal children with or without malocclusion and also children with certain pathologic diseases, to locate the growth and resorption site, variation in the direction and intensity of growth in the individual [110]. The forward growth of the mandible is greater than the maxilla on average of 5mm or more so they mainly focus on the rotation of the mandible during growth [109,110]. Gonial, angle shows the growth, pattern and rotation, of the mandible which, results in different orthodontic malocclusions [2,14]. The increase (obtuse) gonial angle in hyper divergent/high angle case will be shown by the downward, and backward rotation, of the, mandible. The decrease gonial, angle in hypo divergent/low, angle case will be, shown by the upward and forward rotation of mandible [2]. The counterclockwise rotation of the mandible during growth, changes the relationship between the pogonion point and B-point relative to the Frankfort horizontal plane which influences the chin development as a result of jaw growth [109].

Radiographic parameters:

In orthodontics, radiographs used for diagnosis are intraoral radiographs, which are intraoral periapical, bitewing and occlusal view radiographs and extra oral radiographs included orthopantomogram, cephalogram, hand wrist radiographs, xenoradiography, digi radiographs, CT scan, MRI, tomography, occlusogram,

digital subtraction radiography, laser holography, photo cephalometry and cineradiography. Panoramic radiographs [40] is used for the information of the teeth, inclination of the teeth [5, 12, 15,] dental maturation status, facial and mandibular symmetry [101,102], bilateral condyler symmetry [40], trabicular bone pattern and alveolar support to the tooth [43,132]. Also useful in diagnosing extensive, jaw, lesions, changes in anatomical, landmarks such as gonial, angle and ramus, width, cortical bone, width in the inferior, border of the, mandible and calcification, development in oral, cavity or cervical, region. Useful in diagnosing maxillofacial lesions and assessment of other systemic diseases like osteoporosis and for identification and evaluation of cervical anomalies [4,18] . Orthopantomogram is done for all orthodontic patients including class I malocclusion [13, 1,133]. The orthopantomogram have the ability of evaluating mandibular asymmetry [149], mandibular growth direction [107,117,122], the clear evaluation of right and left gonial angle, the relatively low radiation exposure [82-84,148,152] and the greater clinical versatility are the certain advantages over lateral cephalogram [4,121]

Gonial angle:

For the treatment purpose and the mechanics to be used, the pattern of the growth and the divergence of the jaw are to be determined. The gonial angle is one of the common methods of determining jaw divergence [13].

It is the angle between the posterior border of the ramus and mandibular plane [18]. The analysis taken from the lateral cephalogram is done by tracing the cephalometric radiograph [2]. There are different anatomic and derived landmarks traced on the tracing paper which give help in different analysis. Gonial angle is one of the parameter which is also taken from lateral cephalogram. The orthopantomogram is also helpful in analyzing the different angles, vertical and horizontal planes [2.] Marking landmark points the articulare, posterior gonion, lower gonion, menton, gnathion for different analysis. The orthopantomogram is radiograph which is routinely used in dental patients and mostly used in orthodontic cases. The tracing of orthopantomogram also give us facial asymmetry, anterior and posterior facial heights and gonial angle also as called mandibular angle [2, 68,150.]

Objectives of the study

1. To find out the authenticity of lateral cephalometric radiographs and orthopantomogram in assessment of gonial angle value.

2. To check the difference in the values of gonial angle in right and left side of the, orthopantomogram.

3. To find out the gonial angle value range in skeletal class I malocclusions.

4. To find out the gonial angle value range in skeletal class II malocclusions.

5. To find out the gonial angle value range in skeletal class III malocclusions.

6. To evaluate the variation in gonial angle values with age and gender.

Material and methods

Study Settings:

This study was conducted at Orthodontic Department, Institute of Dentistry LUMHS, Jamshoro/ Hyderabad. Sindh, Pakistan.

Study Design:

Cross-sectional study

Study Period:

The duration of the study was six months after approval of synopsis

Sample Selection:

All the samples were selected from Orthodontic Department, Institute of Dentistry LUMHS, Jamshoro/ Hyderabad. Sindh, Pakistan

Sampling Technique:

Non-probability, consecutive sampling

Sample Size:

The sample size was calculated by epitools online calculator using the following values 1.

Mean & SD = 123.62±6.8 (Mean value of gonial angle in lateral cephalogram)

Mean & SD = 122.82±7.54 (Mean value of gonial angle in OPG)

Confidence interval = 95%

Power = 0.5%, Ratio 1:1

The sample size calculated was 174.

Results and Data Analysis

This study consists of 174 total numbers of participants both male and female from ages 12 years to 30 years observing the inclusion and exclusion criteria.

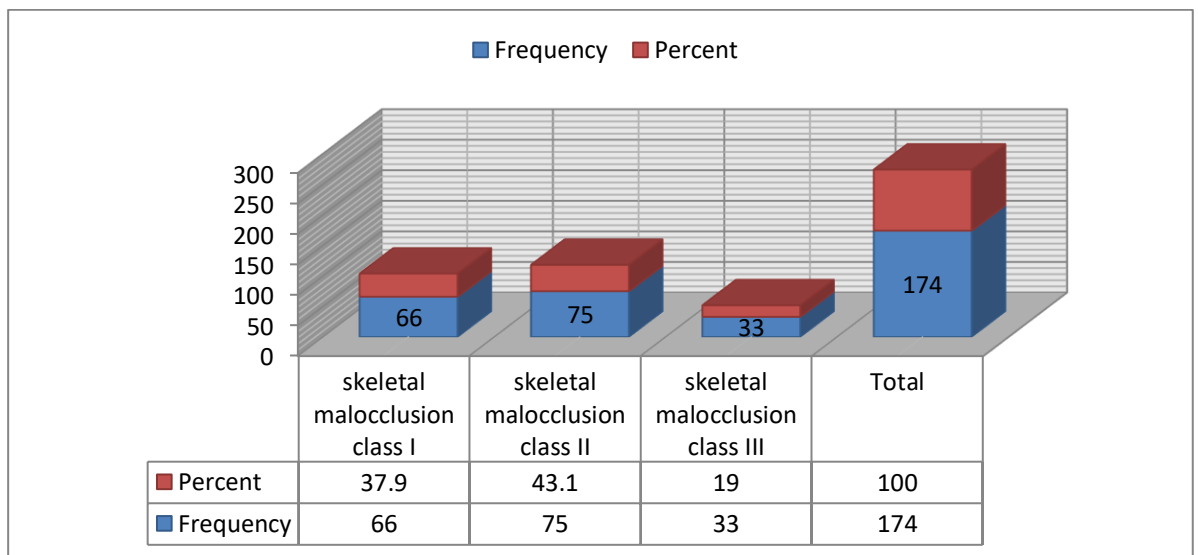**Table 1.** *Statistics of the gender of the participants*

	Total	female	male
Frequency	174	123	51
Percent	100	70.7	29.3

For the distribution of the male and female patient, the frequencies of male participants are 51 in number and the percentages of the male participant are 29.3%. The frequencies of female participants are 123 in number and percentages of female participants are 70.7% shown in the figure no 19.

Table 2. *Descriptive statistics of age (N=174)*

Mean	19.0747
Minimum	12.00
Maximum	30.00

The statistics of age distribution of the participants with the mean age value of the participants are 19.07 years from minimum age of 12 years and maximum age of 30 years shown in the table no 06.

Figure 1. *Skeletal class of the participants*

	skeletal malocclusion class I	skeletal malocclusion class II	skeletal malocclusion class III	Total
Percent	37.9	43.1	19	100
Frequency	66	75	33	174

The frequencies and percentages of skeletal class I are 66 in number and 37.9 %, and that of skeletal class II are 75 in number and 43.1 % while skeletal class III are 33 in number and 19 % shown in figure no 20.

Table 3. *Gonial angle measurement from lateral cephalogram (N=174)*

Minimum	107.00
Maximum	140.50
Mean	123.6264
Std. Deviation	6.84752

Table 4. *Gonial angle measurement from right side orthopantomogram (N=174)*

Minimum	105.00
Maximum	142.50
Mean	121.1178
Std. Deviation	7.24303

Table 5. *Gonial angle measurement from left side orthopantomogram (N=174)*

Minimum	107.00
Maximum	149.00
Mean	123.8132
Std. Deviation	7.42600

GA from LCR

The gonial angles from the lateral cephalometric radiograph in this study have mean value of 123.6264, the minimum and maximum value is 107.00 and 140.50 with the standard deviation of 6.84752 shown in the table number 07.

GA from OPG right side:

The gonial angles from the right side of orthopantomogram in this study have mean value of 121.1178, the minimum and maximum value is 105.00 and 142.50 with the standard deviation of 7.24303 shown in the table number 08.

GA from OPG left side:

The gonial angles from the left side orthopantomogram in this study have mean value of 123.8132, the minimum and maximum value is 107.00 and 149.00 with the standard deviation of 7.42600 shown in the table number 09.

Table 6. *Age variation Mean*

Age of the participants	Gonial angle measurement from lateral cephalogram
12.00	127.8500
13.00	125.5000
14.00	128.7000
15.00	124.4000
16.00	123.7667
17.00	125.0313
18.00	120.6842
19.00	120.8500
20.00	121.7667
21.00	124.2857
22.00	122.2813
23.00	120.2778
24.00	127.1000
25.00	125.0000
26.00	124.3750
27.00	124.1250
28.00	124.6000
29.00	119.0000
30.00	122.2500

To calculate the variation in the values of GA from lateral cephalogram between 12 to 30 years of age. The mean gonial angle shows variation with increasing values in the irregular pattern from the age 12 years to 24 years and then decreasing the mean values of gonial angle from age 24 years to 30 years same in the irregular pattern which is shown in the table number 10.

Table 7. *Gender-based mean gonial angle from lateral cephalogram*

Male	123.4118
Female	123.7154

To calculate the difference in the values of gonial angle in male and female participants in this study. The mean gonial angle value in the male gender is 123.4118 and the mean gonial angle value of female gender is 123.7154. There is no, significant, difference, found in the values, of gonial, angle from lateral

cephalogram, in different malocclusion, groups, there values are shown in the table number 11.

Table 7. *Gonial Angle in skeletal class I malocclusion from LCR*

Mean	123.3561
Std. Deviation	6.55202
Minimum	107.00
Maximum	140.50

Table 8. *Gonial Angle in skeletal class II malocclusion from LCR*

Mean	124.1533
Std. Deviation	6.90377
Minimum	110.00
Maximum	140.00

Table 9. *Gonial Angle in skeletal class III malocclusion from LCR*

Mean	122.9697
Std. Deviation	7.40454
Minimum	108.00
Maximum	134.00

GA, in skeletal, class I, malocclusion:

The mean, value of gonial, angle, in skeletal class, I malocclusion, participants, from LCR are 123.3561 with the range of minimum value of 107.00 and maximum value of 140.50 with the standard deviation of 6.55202 shown in the table number 12.

GA, in skeletal, class II , ,malocclusion:

The mean, value of gonial, angle in skeletal class, II participants, from LCR are 124.1533 with minimum range of 110.00 and maximum range of 140.00 with the standard deviation of 6.90377 shown in the table number 13.

GA, in skeletal, class III, malocclusion: The mean, value of gonial, angle in skeletal, class III, malocclusion participants are 122.9697 with minimum value range of 108.00 and maximum value range of 134.00 with the standard deviation of 7.40454 shown in the table number 14.

Discussion

This study was done to determine the value of gonial angle from lateral cephalogram and orthopantomogram. To check the reliability between these two radiographs and between right and left side of the orthopantomogram. To find out the variation in the gonial angle value with age and gender and also the variation according to the sagittal skeletal malocclusion classes. Based on the inclusion and exclusion criteria 174 total numbers of participants were selected divided into different skeletal malocclusion groups according to ANB angle. Tracing was done on the radiographs both lateral cephalogram and orthopantomogram to evaluate the value of gonial angle between tangent to ramal plane and tangent to inferior border of the mandible according to tweed's mandibular plane to avoid the discrepancy in the mandibular plane.

The GA shows form and shape of the mandible, and plays, an important, role in predicting, the mandibular, growth, direction, effect on the facial changes and on the inclination of the mandibular teeth5. The LCR and OPG useful for measuring GA and mandibular inclination so the purpose of this study was to check the reliability of the LCR and OPG in assessing GA. Thilangrani et Al in evaluating the gonial angle in three different malocclusion classes patients from lateral cephalogram and orthopantomogram using Tweed's, Steiner's and Down's mandibular planes. He found no statistically significant difference in GA values between the radiographs but they find out the accurate reliability of the Tweed's mandibular plane to assess GA in comparison to Steiner's and Down's mandibular planes 2. In the present study we used Tweed's mandibular plane to assess GA value from the radiographs as its accuracy was studied in the previous literature.

Determining the reliability of the radiographs by taking 80 patients with skeletal class I malocclusion Adil S et Al measure the mean value of gonial angle of 125.4º from lateral cephalogram, 123.2º from the right side of the orthopantomogram and 123.8º from the left side of the orthopantomogram. They concluded the significant difference between the LCR and OPG and also evaluate the equal reliability between right side and left side of the orthopantomogram. To test the reliability of the OPG instead of LCR for measuring gonial angle they conclude that large scale study is further required 1. In the present study by taking 174 participants with different skeletal malocclusion groups. The results are in contrast to the above study because we did not find any significant difference in GA values from LCR and OPG but the reliability of the two sides of the OPG was equally accurate and was same as find by Adil S et Al. Larheim and Svanaes found no significant difference between right and left side of OPG and observe equal reliability of OPG and LCR 6, the results of our present study also follow the same reliability. Slagsvold and Pedersen report that gonial, angle is not, correctly, measured in the lateral, cephalograms unless, the X-ray film is parallel, to the angle, plane. The gonial, angle is the geometrical mean of the angle measured between the right and the left gonial angle in a lateral cephalogram 7.

Nohadani and Ruf studied the gonial angle values, in the posterior, and lateral, side of the mandible, from panoramic radiographs are not influenced by the images, distortion and are more reliable 7. GA measuring from LCR has the

complication of superimposition of the images which was not present in the OPG, and OPG also have less radiation doses but the inclination of the mandibular body and the direction of the X-ray beam incidence make it difficult to assess GA from OPG4. Kati G et AL taking 50 patients of Angle's Class I malocclusion and found equal reliability of the radiographs measuring the values of mean gonial angle of 122.22° from cephalometric radiograph and 121.13° from panoramic with no statistically significant difference but the problem in determination of GA from lateral cephalometric due to the superimposition of the images which was not present in the right side and left side of the orthopantomogram16. Akcam et AL studying the skeletal vertical dimension of craniofacial structures in lateral cephalogram and compared with orthopantomogram and explain that skeletal vertical cephalometric parameters from orthopantomogram should be taken with great care because of their low predictability percentages23.

Mattila et al found GA of 128.6º from LCR and 127.8º from the OPG while Shahabi M et Al found smaller GA from LCR and OPG with the values of 125.00º and 124.17º respectively, with no significant difference 3,10,41. Fisher-Brandies et Al describe the value of GA from OPG is 2.2-3.6º less than that of the values of GA from lateral cephalogram11. In the present study we found the mean value of GA of 123.62º from lateral cephalogram and 121.11º from right side of OPG and 123.81º from left side of the OPG which are smaller and contradicting the above studies on the basis of the values but in favor on the basis of significance as we also found no statistically significant difference in the mean or standard deviation values of the gonial angle.

As the gonial or mandibular angle is important for the gender assessment in forensic dentistry Belaldavar C et AL studying the gender assessment by digital analysis of the gonial angle from lateral cephalogram found the values of gonial angle of 122.7° for females and 121.1° for males with an accuracy rate of 56.3%, gender evaluation identified (61.9%) females being more accurately than males (50.3%) 17. In studies about African and Egyptian populations the gonial angle value in male gender was found to be greater than females usually with the mean range of 3−5º greater in males than females. Jensen and palling and Casey and Emerich also found greater gonial angle of 3–5º in females than in males 24. Raustia et al declared that gender have no effect on the variation of GA 6, 37. Booshehri ZM results was same as Altonen results having no change in the GA with gender, age and type of malocclusion from OPG and LCR 6. Gungor et Al Found variation in the left GA between the genders6, 44. Huumonen et Al and Xie and Ainamo found the larger gonial angle in the females than males due to influence of the masticatory forces7,8. Fisher-Brandies et Al obtained 2.2-3.6º greater GA value from the lateral cephalogram than the orthopantomogram 3. While we found the mean difference of GA of 2.5º and standard deviation of 4.03 between LCR and right side OPG, mean GA of 2.6º and standard deviation of 4.04 between two right and left side of OPG and mean difference of .186º and standard deviation of 3.99 between left side of OPG and LCR. Comparing GA from LCR and OPG in patient with skeletal class I Shahabi M et Al found the gender variation of GA of 125.04º in females and 124.90º in males from LCR while GA of 124.39º in females and 123.68º in male from OPG 3. In the present study the gender variation in GA from LCR we found the value 123.71º in females and 123.41º in males with no significant difference.

Ghosh S et Al studied the changes relationship of the gonial angle with age, gender, and loss of tooth, they take 1000 participants (500 males and 500 females) and found increase gonial angle with increasing age in both males and females 113, female participants have high gonial angle values than male participants because of the greater masticatory forces in males than females, also increase mean gonial angle with loss of tooth as from the complete dentulous state to the partially dentulous state and then to fully edentulous state in both females and males participants due to masticatory forces and the loss of intermaxillary support due to the absence of teeth is an additional factor24. Jensen and Palling found the increase in the gonial angle with increase age and become obtuse24. Enlow et al stated that with every remodeling alteration it is not necessary that the gonial angle must change. Casey and Emerich also found no change in the mandibular angle occur only with age. Ohm and Silness stated that there is no strong relation between the size of the gonial angle and age 24, 144,145. In the present study we take 174 participants from age 12 years to 30 years and found increase in the GA value from age 12-24 years in the irregular manner and then decrease GA values from 24-30 years in the same pattern contradicting the above studies.

Changes in the gonial angle occur during lifetime. Gonial angle in a newborn range from 135° to 150°, range from 130° to 140° upon completion of the deciduous dentition, and after the eruption of the second permanent molars between 120° and 130°. Gonial angle in adults is 100° to 120º while in an old adult increase in the size of the angle occur to 140° to 150° 42. To documented the effect of the age and gender on the mandibular ramus and condyler body Shilpa B et AL studied 60 patients from age 35-65 years and measure gonial angle to check its significant contribution on the facial profile of the patients. The mean gonial angle values of both sides were calculated. The mean gonial angle values in males ranged from 114.8° ± 8.341° to 122.3° ± 8.722° while the mean gonial angle values in females ranged from 114.7° ± 5.227° to 122.65° ± 5.413° finding the results that gender does not had significant effect on the gonial angle while age significantly influence on the gonial angle 29. Hawraa Noori Atallah et AL concluded that gender affect the size of the gonial angle with more gonial angle in females than male but does not affect the inferior alveolar canal. Age does not affect the size of the gonial angle and the inferior alveolar canal measurements but there was a significant correlation between the gonial angle and the inferior alveolar canal measurement, the size of the gonial angle and the position of the inferior alveolar canal can predict eachother33. Shende BN et AL found that infra bony landmarks, the mandibular canal from orthopantomogram are not a reliable alternative for the measurement of the gonial angle36.

Park HS et Al found strong correlation between two radiographs in class III patients, the value of GA from OPG is 125.49º and GA value is 127.50º from lateral cephalogram. They obtained less GA from OPG than LCR and the panoramic radiographs shows 2.00 (range 1.70-2.31, 95% confidence interval) less than lateral cephalogram. while in the present study the value of GA from right side OPG is less than LCR while that of left side OPG is greater than LCR with the range of 0.18-2.50º.

The mandibular shape correlates with the occlusal condition and also with the function of the masticatory muscles. To find the effect of tooth loss on the shape of the madibular base Huumonen et al found larger gonial angle and smaller ramus and condylar height in edentulous subjects on both side as compared with dentate subjects so its importance of rehabilitation as long as possible to maintain good functioning of the masticatory muscles 8,. Nohadani et Al in 2008 measured facial vertical and dentoalveolar changes as on lateral cephalometric and panoramic radiographs and found that in the panoramic radiographs angular values are more reliable than vertical values and are not useful for measuring the facial vertical dimensional changes9, 28. Nejad MA et Al checking the reliability of radiographs to determine GA and FMPA in different vertical skeletal pattern, they found the GA value for the low angle or horizontal growers 115.5º or less, normal angle and normal growers with the mean GA value of 123.3º and range of ±7º and that of vertical angle or vertical growers GA value 133.7º or greater 14. Alhaija, et Al, studying, the potential of orthopantomographic, radiographs to evaluate, the mandibular inclination, and steepness, by gonial, angle measurement which effects the skeletal vertical pattern and found that orthopantomogram is accurately and reliable as use for measuring gonial angle by comparing and correlating the values with lateral cephalogram values23.

Rehman AS et Al take 91 patients of different vertical skeletal height, they calculated the mean Gonial angle value in hypo divergent are 119.77°±6.05°, mean GA in normal divergent are 123.66° ±5.50° in hyper divergent are 127.36° ±7.52° 23. Panneerselvam et AL studying the effect of the gonial angle on mandibular angle fracture and measure the values of gonial angle of normal vertical height range fixed at 121.8°, the value larger than 128° was considered a high gonial angle and the values smaller than 115.6° was considered a low gonial angle. They concluded those high gonial angles are at increased risk for angle fracture30. Bibi T et Al found a significant correlation between radiographs and in determining gonial angle for predicting facial vertical pattern, they found, panoramic radiography, is as reliable, as lateral, cephalogram and can be used as alternative to lateral cephalogram21. Trivedi B et Al it's comparing orthopantomogram with that of cephalometric findings by measuring gonial angle, mandibular plane angle and ratio between the lower third anterior facial height to posterior facial height, they found high correlation and no statistically significant difference between OPG and LCR and stated that there is no need of taking an additional lateral cephalometic radiograph when orthopantomogram is available22. Oshagh M et AL revealed that orthopantomogram is a helping tool to provide information about the sagittal and vertical dimensions of both jaws 40. Rıdvan Oks¸ayan et AL found the values of gonial angles determined from lateral cephalometric radiograph and panoramic radiographs with no significant differences between Class I, II, and III malocclusion group39. The present study about the GA determination in different sagittal skeletal pattern we measured the value of mean GA in skeletal class I is 123.3561º and in class II is 124.1533º while mean GA in skeletal class III is 122.9697º without any statistically significant difference

Conclusions

There was no significant difference found when comparing the value of the gonial angle from the lateral cephalogram and both the right and left sides of the orthopantomogram in different sagittal skeletal malocclusion groups. The two radiographs LCR and OPG both are found to be reliable in the determination of the gonial angle. The superimposition of the gonial angle is found in the LCR. This overlaid error of the LCR was not present in OPG and also has the advantage of the decreased radiation to the participants. Based on gender variation in gonial angle we found equal reliability with no statistically significant difference. Variation with increasing age the value of gonial angle also increases in the random way from age 12 years to 24 years and also decreases in the values of gonial angle from age 24 years to 30 years. There is no statistical significant difference found in the mean values of gonial angle in the sagittal, skeletal class I, class II, and class III, malocclusion groups.

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