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Correlation of Condylar Guidance, Labio-Lingual Inclination Of The Upper Central Incisors, Incisal Guidance And Y-Axis Between Different Classifications Of Skeletal Malocclusion In Antero-Posterior Plane: A Clinical And Radiographic Study.

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Abstract

Aim: To evaluate and compare the correlation between condylar guidance angle (CGA) obtained by protrusive interocclusal records mounted on semi-adjustable articulator with panoramic and lateral cephalogram radiograph tracings and anterior guidance angle, axial inclination of maxillary central incisor and Y- axis angle obtained by lateral cephalogram radiograph tracings in dentulous population.

Materials and methods: Forty five dentulous subjects between age group of 14–22 years, free of signs and symptoms of any temporomandibular disorders and facial asymmetry were selected. The condylar guidance angle was determined by protrusive interocclusal records and transferred to a semi-adjustable articulator through a face bow. The condylar guidance angles obtained were tabulated. The sagittal outline of the articular eminence and glenoid fossa were traced on panoramic and lateral cephalogram radiographs. The sagittal condylar path inclination was constructed. This was related to the S-N plane on radiograph to determine the radiographic condylar guidance angle. The comparison of protrusive interocclusal records was done with the angles obtained

by panoramic and lateral cephalogram radiograph tracings.

Statistical analysis: The correlation between different skeletal sagittal malocclusions with Incisal inclination incisal guidance, condylar guidance & growth axis will be done using Pearson's correlation. The four groups were compared for differences using one-way analysis of variance (ANOVA). Post-hoc individual comparisons are done using LSD (Least Significant Difference) method. All analyses was done at alpha 0.05 (95% C.L.).

Result: A significant difference in the CGA of three skeletal relationships was seen, with Class II having a steeper angle than the other two. Among the various methods used, a correlation was found between the clinical and the protrusive method

Keywords: Condylar guidance, Lateral cephalogram, panoramic radiograph, Interocclusal records

Introduction

One of the essential fundamentals of good orthodontic treatment result is achieving balanced occlusion which is harmonious with all the related structures of Stomatognathic system. In manifesting the final occlusion, anatomy of Temporomandibular Joint (TMJ) and the cuspal inclinations of posterior teeth are the posterior influencing factors while incisal guidance acts as the anterior influencing factor. The TMJ, masticatory muscles and anterior teeth are the structures that determine patterns during any given type of movement of the mandible; unique anatomic relationships of these structures combine to dictate a precise and repeatable pathway.[1] This maintains harmony of the occlusal condition. The posterior teeth must pass close to but not contact their opposing teeth during such mandibular movements.

Condylar guidance is considered to be a fixed factor and is unalterable in a healthy patient. The anterior guidance is considered to be a variable rather than a fixed factor. It can be altered by dental procedures such as restorations, orthodontia, and extractions. It can also be altered by pathologic conditions such as caries, habits, and tooth wear. In antero-posterior movements, the angle at which condyle moves away from a horizontal reference plane is referred to as the Condylar Guidance Angle (CGA).

As the condyle moves out of the centric relation position, it descends along the articular eminence of the mandibular fossa. The rate at which it moves inferiorly as the mandible is being protruded depends on the steepness of the articular eminence. If this surface of the eminence is very steep, in turn, the condyle will describe a steep vertically inclined path and vice versa. Since the separation between the teeth is increased the cusps of the teeth can be steeper while still producing the necessary disocclusion which is desirable in the natural dentition. Thus, a steeper condylar path allows for steeper cuspal inclines on the teeth. The incisal path is a function of the relationship between the anterior teeth. Greater the vertical overlap greater steeper is the incisal path resulting in steeper cuspal inclines. When the horizontal overlap is increased the mandible assumes a more horizontal pattern of movement and lesser is the guidance offered by the anterior teeth resulting in shallower cuspal anatomy.[2]

TMJ determines or controls the manner in which the posterior portion of the mandible moves.[18]Anterior teeth determine how the anterior portion moves. Incisal guidance is the influence on mandibular movements provided by the contacting surfaces of the maxillary and mandibular anterior teeth. The steepness of the incisal guidance is influenced by the horizontal and vertical overlap of the anterior teeth as well as palatal morphology of upper anterior. The incisal guidance is controlled by hard tooth surfaces contacting opposing hard tooth surfaces.

Muscles of mastication and the temporomandibular joints control the movements of the mandible when the teeth are out of functional contact. Teeth play a progressively greater role in directing movements of the mandible from the instant of first tooth contact. This continues until all teeth are in full functional contact.

A study by Ross[3] IF shows, several factors control incisal guidance and determine its significance. These are overjet (horizontal overlap), incisal level, labiolingual curve, and overbite (vertical overlap). The incisal levels of both the maxillary and mandibular anterior teeth also contribute to incisal guidance. The incisal level of the mandibular teeth may be regular or irregular. If the level is irregular, certain teeth will be higher than others. The teeth in supraocclusion will exert greater force and will, in turn, have greater force exerted on them than will the adjacent teeth that are in infraocclusion.[3-8] Another aspect of the incisal level is the height of the anterior teeth in relation to the height of the posterior teeth. Supraocclusion may result from overeruption of the anterior teeth or from excessive wear or loss of posterior teeth. If the anterior teeth are in supraocclusion, they may exert excessive force that will loosen and cause flaring of the opposing maxillary teeth.

Andrews LF[9] introduced the six keys to normal occlusion. The Third key to normal occlusion was Axial (Labio-lingual) Inclination of tooth. Upper and lower anterior crown inclinations are intricately complementary and significantly affect overbite and posterior occlusion. Properly inclined anterior crowns contribute to normal overbite and posterior occlusion. In present study we used Axial Inclination of upper central incisor intersect with SN plane and forms Axial inclination Angle[10].

In present study, Y axis also known as Growth axis, Y axis angle was form by S-Gn (Y axis) intersect with SN plane. The Y axis indicates the downward, backward or forward position of the chin in relation to the upper face. In present study Y axis was helpful for diagnosis and treatment planning by showing the growth pattern in each type of malocclusion. It is important to examine each of these structures carefully and appreciate how the anatomic form of each can determine the occlusal morphology necessary to achieve an optimal occlusal relationship. Thus, it is considered important to assess the correlation between condylar guidance and the growth axis which are natural genetically dictated elements with anterior guidance and axial inclination of Maxillary central incisor which are likely to be affected by local environmental factors or can be altered with/during treatment[11].

Materials and Methods

Forty five (age group 14-22 years) Interocclusal records with Semi-adjustable Articulator, Lateral Cephalographs and Orthopantomogram (OPG) taken with standard positioning guidelines with standardized machine (KODAK 80000 C DIGITAL PANORAMIC AND CEPHALOMETRIC SYSTEM) with different sagittal skeletal malocclusions will be selected from the Out-Patient Department (OPD) in Department of Orthodontics and Dentofacial Orthopadics of Bharati Vidyapeeth Dental College and Hospital, Navi Mumbai.

i) Interocclusal records

Maxillary and mandibular impressions were made using Irreversible hydrocolloid (Zelgan 2002; Dentsply, India) Impression material and casts were made using Type III dental stone (Kalstone, Kalabhai, India). Each Patient was instructed to move his/her mandible forward by Approximately 6 mm and/or edge to edge contact in anterior Using Aluwax, and a protrusive record was obtained. Using face-bow transfer, the maxillary cast was mounted on the semi-adjustable articulator (HANAU TM Wide-Vue, Whip Mix Corporation, USA) and the

mandibular cast was mounted using the patient's maximum intercuspation record.

Figure 1: Protrusive interocclusal record with semi-adjustable articulator (HANAU).

ii) Lateral Cephalograph & Panoramic Radiographs

Panoramic radiographs and lateral cephalogram will be obtain from the Department of Orthodontics and Dentofacial Orthopedics. Tracings of the radiographic images will be made on a Lead Acetate tracing sheets. A horizontal reference line is mark by joining the Sella to Nasion point. The most superior and the most inferior points of the curvatures will be identified. These two points was connected by a straight line representing the mean curvature line. Condylar Guidance angles is made by the intersection of the mean curvature line and the horizontal reference line tracing will be measured.

Methodology

The classification of malocclusion in different patients will be carried out with the help of clinical examination, study model analysis & cephalometric readings. All 45 Lateral Cephalograph & OPG will be divided into groups as follows:

Group I: Angle's Class I malocclusion (ANB 2˚) 15 Patients

Group II: Angle's Class II div 1 malocclusion (ANB > +5˚) 15 Patients

Group III: Angle's Class II div 2 malocclusion (ANB > +5˚) 9 Patients

Group IV: Angle's Class III malocclusion (ANB <0˚) 6 Patients

Following planes and angles were established in the Lateral Cephalogram as per the standard landmarks used for them:

1. Horizontal reference plane: Sella-Nasion Plane (SN)

2. Axial inclination angle: Angle formed by line joining upper central incisal tip & its apex (Long axis of central incisor) to SN plane.

3. Growth axis angle: Y-axis (S - Gn) to SN plane.

4. Incisal Guidance Angle (IGA): A line passing through the palatal surface of upper central incisor from highest contour of cingulum till the incisal edge (U1 to SN plane).

5. Condylar Guidance angle: Inclination of Articular Eminence which is measured from the deepest point in the glenoid fossa (crest) to the point of height of contour (crest) on the articular eminence. These two points are connected by A straight line known as a Mean Curvature line, which is intersect with SN plane and form Condylar Guidance angle.

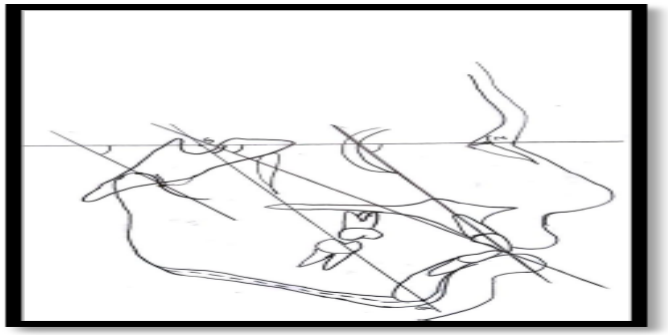


Figure 2: Cephalometric tracing for CGA, IGA, Axial Inclination and Y axis angle.

Following readings were taken from OPG

***Condylar Guidance Angle*:** Inclination of Articular Eminence which is measured from the deepest point in the glenoid fossa (crest) to the point of height of contour (crest) on the articular eminence. These two points are

connected by A straight line known as a Mean Curvature line. Angle measured between horizontal reference plane & intersection of the mean curvature line.

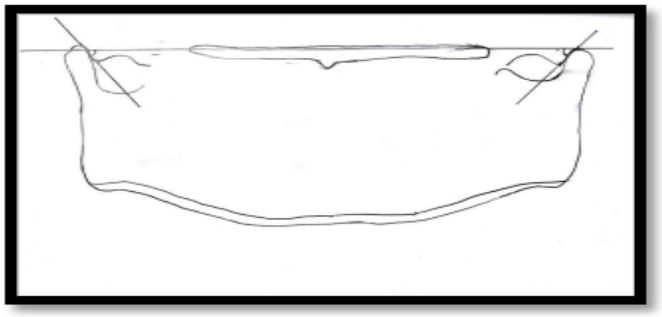


Figure 3: Panoramic radiograph tracing for CGA.

Results

All data was entered into a Microsoft Office Excel (version 2016) in a spreadsheet which was prepared and validated for the study data. Data was entered and checked for errors and discrepancies. Data analysis was done using windows based 'MedCalc Statistical Software' Version 17.8.2 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017).

Study Hypothesis

Null Hypothesis (Ho): There is no correlation between different skeletal sagittal malocclusions with Incisal inclination, incisal guidance, condylar guidance & growth axis.

Alternate Hypothesis (H1): There is a positive correlation between different Sagittal malocclusions with Incisal inclination incisal guidance, condylar guidance & growth axis.

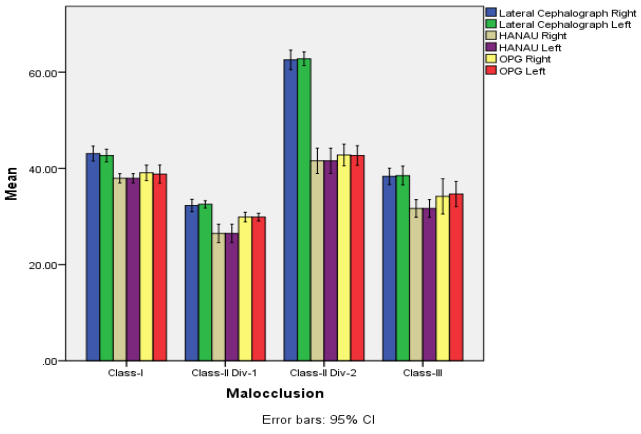
Data expression

The values for the angles will be expressed as means with SD/SEM.

Statistical Analysi

The correlation between different skeletal sagittal malocclusions with Incisal inclination incisal guidance, condylar guidance & growth axis will be done using spearman's rank correlation. The four groups were compared for differences using one-way analysis of variance (ANOVA). Post-hoc individual comparisons are done using LSD method.

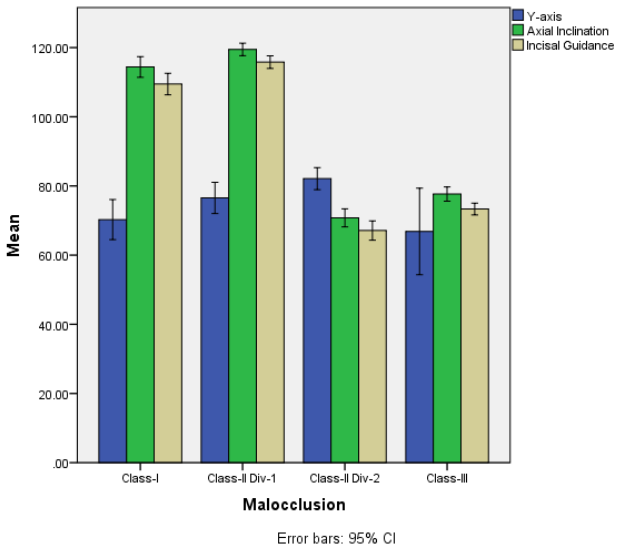
All analyses were done at alpha 0.05 (95% C.L.).Data analysis was done using windows based 'MedCalc Statistical Software' Version 17.8.2 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017). The values for the angles will be expressed as means with SD/SEM. The correlation between different skeletal sagittal malocclusions with Incisal inclination, incisal guidance, and condylar guidance & growth axis will be done using spearman's rank correlation. The four groups were compared for differences using one-way analysis of variance (ANOVA). Post-hoc individual comparisons are done using LSD method. All analyses were done at alpha 0.05 (95% C.L.). Values of all parameters were obtained from Lateral Cephalograph, OPG and Semi-adjustable Articulators (HANAU) in Class I, Class II div 1, Class II div 2, Class III malocclusion. CGA measured with Three methods as, 1) CGA from Lateral Cephalograph, 2) CGA from OPG, 3) CGA from Semi-adjustable Articulator (HANAU).Where the other parameters were measured on Lateral Cephalograph such as, IGA, Axial Inclination and Y axis.



Graph 1: Comparison of mean values for all three methods in all four types of malocclusion on right and left sides.

CGA mean values from Lateral Cephalograph of right and left side condyle was determined in Class I malocclusion patients were 43.07 and 42.67 respectively, In Class II div 1 patients mean values for right side was 32.27 and left side was 32.53. For Class II div 2 cases mean for right side was 62.56, where on left side 62.78 and in Class III malocclusion values on right side was 38.33 and left side 38.5.

mean values obtained from OPG, for Class I malocclusion on right side was 39.07 and on left side was 38.8, for Class II div 1 on right side as 29.87 and left side 29.87, for Class II div 2 on right side 42.78 and 42.67 on left side, for Class III malocclusion on right side was 34.17 and on left side 34.67. Graph 1, showed CGA mean values from Semi-adjustable Articulator (HANAU) on right side was 37.93 and on left side was 37.93 in class I malocclusion patients, for Class II div 1 right side 26.47 and left side 26.47, for Class II div 2 malocclusion patients mean values were 41.56 on right and 41.56 on left side, for Class III malocclusion patients mean values were 31.67 on right and 31.67 on left side. (Graph 1)



Graph 2: Comparison of mean values for Y- Axis, Axial Inclination, Incisal Guidance Angle obtained from Lateral Cephalograph in all four types of malocclusions.

Graph 2 showed, other Lateral Cephalograph parameters mean values for Y axis was 70.27 for class I malocclusion, 76.53 for Class II div 1malocclusion, 82.11 for Class II div 2 malocclusion, 66.83 for Class III malocclusion. Mean values for IGA for Class I malocclusion was 109.47, 115.80 for Class II div 1 malocclusion, 67.11 Class II div 2 malocclusion, 733.33 Class III malocclusion. Axial inclination mean values for Class I malocclusion was 114.40, for Class II div 1malocclusion was 119.47, for Class II div 2 malocclusion was 70.78, for Class III malocclusion was 77.67. Significant (p value < 0.05) correlation is observed between CGA from Lateral Cephalograph when compared with CGA from HANAU and OPG. The correlation is more significant for CGA from OPG than that of CGA from HANAU. The correlation between CGA from Lateral Cephalograph and y axis angle is positive but non-significant (p value > 0.05).

Significant (p value < 0.05) negative correlation is observed between CGA from Lateral Cephalograph when compared with Axial Inclination and Incisal Guidance. Significant (p value < 0.05) positive correlation is observed between CGA from HANAU and CGA from OPG (correlation value = 0.826). The correlation between CGA from HANAU and y axis is positive but non-significant (p value > 0.05). Significant (p value < 0.05) negative correlation is observed between CGA from HANAU when compared with Axial Inclination and Incisal Guidance. The correlation between CGA from OPG and y axis is positive but non-significant (p value > 0.05). Significant (p value < 0.05) negative correlation is observed between CGA from OPG when compared with Axial Inclination and Incisal Guidance. Non-Significant (p value > 0.05) negative correlation is observed between Y axis when compared with Axial Inclination and Incisal Guidance. Significant (p value < 0.05) positive correlation

is observed between Axial Inclination and Incisal Guidance.

Observations

Correlation between parameters

Table 1: Correlation (Pearson's) between different parameters (pooled)

		Condylar Guidance (LC)	Y-axis	Axial Inclination	Incisional Guidance	Condylar Guidance (OPG)	Condylar Guidance (HANAU)
Condylar Guidance (LC)	Pearson Correlation	1	.220	.388	-.380	.695**	.960**
	Sig. (2-tailed)		.352	.091	.099	.001	.000
	N	20	20	20	20	20	20
Y-axis	Pearson Correlation	.220	1	-.527*	-.024	-.479*	.055
	Sig. (2-tailed)	.352		.017	.921	.032	.819
	N	20	20	20	20	20	20
Axial Inclination	Pearson Correlation	.388	-.527*	1	-.649**	.757**	.554*
	Sig. (2-tailed)	.091	.017		.002	.000	.011
	N	20	20	20	20	20	20
Incisional Guidance	Pearson Correlation	-.380	-.024	-.649**	1	-.325	-.534*
	Sig. (2-tailed)	.099	.921	.002		.162	.015
	N	20	20	20	20	20	20
Condylar Guidance (OPG)	Pearson Correlation	.695**	-.479*	.757**	-.325	1	.779**
	Sig. (2-tailed)	.001	.032	.000	.162		.000
	N	20	20	20	20	20	20
Condylar Guidance (HANAU)	Pearson Correlation	.960**	.055	.554*	-.534*	.779**	1
	Sig. (2-tailed)	.000	.819	.011	.015	.000	
	N	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 1: One-way ANOVA (ANOVA Table)

		Sum of Squares	df	Mean Square	F	p
Condylar Guidance (LC)	Between Groups	3527.133	3	1175.711	133.021	<0.0001
	Within Groups	141.417	16	8.839		

	Total	3668.550	19			
Y-axis	Between Groups	1639.367	3	546.456	148.611	<0.0001
	Within Groups	58.833	16	3.677		
	Total	1698.200	19			
Axial Inclination	Between Groups	232.467	3	77.489	18.761	<0.0001
	Within Groups	66.083	16	4.130		
	Total	298.550	19			
Incisional Guidance	Between Groups	7050.783	3	2350.261	126.118	<0.0001
	Within Groups	298.167	16	18.635		
	Total	7348.950	19			
Condylar Guidance (OPG)	Between Groups	608.417	3	202.806	47.313	<0.0001
	Within Groups	68.583	16	4.286		
	Total	677.000	19			
Condylar Guidance (HANAU)	Between Groups	740.417	3	246.806	201.645	<0.0001
	Within Groups	19.583	16	1.224		
	Total	760.000	19			

Discussion

TMJ is a synovial joint that allows a range of movements for function such as speech, suckling, swallowing and mastication. The path traversed by a condyle in relation to the articular eminence often called as a Condylar path, is one when the mandible moves either protrusively or laterally from centric relation position. Prasad K, Prasad BR[12] stated that, when mandible moves forwards, the condyle and its assembly move anteriorly and a translatory motion results. The guidance offered by the articular eminence of the mandibular fossa is dependent on the steepness of the articular fossa and is called the Condylar Guidance. Condylar guidance in the mechanical form as depicted in an articulator is located in the upper posterior region of an articulator that controls the movement of the mobile member of articulator.[13] There are various methods to record condylar guidance angle. The earliest methods employed to register the condylar guidance angle were the "protrusive wax check bites" introduced by Christensen (1905) and the graphic method introduced by Gysi (1908). Since then, several authors have carried out studies to determine the HCG using various methods and compare the variability between different registration methods, articulator systems, and recording materials. The main drawback of the interocclusal wax records is the inherent dimensional instability of the recording medium, i.e. wax. Santos P[14] found computerized condylography to evaluate the eminence inclination and another method was cephalometric study. Galagali G, Kalekhan S[15] used clinical protrusive records of upper and lower cast with panoramic and lateral cephalograph method. Tangent method on radiograph introduced by Sweta Singh,

Samiran Das[16], they used protrusive method along with radiographic tangent method.

Issacson DA[17] and Preti G[18] rely on average values of condylar guidance, which ranges from 22° to 65°. According to Angle (1948) had proposed that, the sagittal condylar guidance coincided more or less with the height and slope of the posterior surface of the articular tubercle. The author stated that "an arbitrary plane of motion of the mandibular condyle was set as a line from the apex of the articular eminence tangent to the fossa- eminence transition zone." This line was labelled the eminence slope.

In general, it was seen that participants with Class II skeletal relation have a significantly higher angle of CGA which was in accordance with the reports of Ingervall[18] and participants with Class III skeletal relation had a significantly lower angle of HCG as compared to the Class I participants. Santos P conclude in his study, increasing sequence of Class II div 1, followed by Class III and Class I and the upper value Class II div 2. It is important to identify eminences with high angles of inclination which are frequently related to a high tendency to TMJ dysfunction and should be taken into account for diagnostics and treatment planning[19]. The results of the present study were in accordance with findings in Ingervall's study.[20]

Widman[21] had reported an inverse relation between the angle of articular eminence and the occlusal and mandibular planes. It means steeper the articular eminence, the more horizontal the occlusal and mandibular planes. These results suggested that brachiocephalic facial type tends to have more vertical articular eminence angles and dolichocephalic facial type would tend to have a more flattened articular eminence angle.

In present study, the difference in the values obtained by the three methods is contrast with the findings of authors such as Galagali G[22] and Singh S[23] who reported that radiographic methods yielded greater value of CGA as compared to clinical methods.

In present study, the correlation between CGA from Lateral Cephalograph and y axis angle is positive but non-significant (p value > 0.05). It showed that, CGA does affect the growth pattern of mandible. Similar study by Xiao Yao, Qin Pu[24] vertical displacement of condyle movement during mandibular protrusion of Class II div 2 patients is larger than that in normal occlusion group, it may be correlated to the overbite, condylar position and incisal inclination. The correlation between CGA from HANAU and y axis is positive but non-significant (p value > 0.05). Non-Significant (p value > 0.05) negative correlation is observed between Y axis when compared with Axial Inclination and Incisal Guidance. It means that, growth pattern of mandible is not correlated to morphology of tooth and inclination of the tooth. Growth pattern does not affect the morphology and inclination of upper central incisors.

Christensen and Slabbert[25] who reported that "No radiographically determined sagittal condylar guidance angle coincided with that obtained with the use of intra- oral records. The radiographically determined angle showed a greater mean value than that determined by intra- oral records." While comparing the two radiographic methods, Non-Significant (p value > 0.05) negative correlation is observed between Lateral Cephalograph Right and Left when compared with HANAU Right & Left condyle values and OPG Right & Left condyle.

In present study, significant positive correlation found between axial inclination and incisal guidance. Therefore, if the axial inclination changes then incisal guidance will

also change. Incisal guidance is also dependent on morphology of the cingulum, which might vary from person to person. When CGA from lateral cephalograph is correlated with IGA and Axial inclination, correlation is significant and negative, which shows condylar guidance does not affect to axial inclination of upper center incisor and morphology of upper center incisor. On contrary, Zezo[26] stated that condylar guidance and incisal guidance are correlated.

A number of factors could account for the difference in registered values between the clinical and the radiographic methods with the latter yielding higher values.[27]The difference could be partly due to errors of the clinical method and cephalometric method. Errors of the clinical method can be attributed to the error in the registration technique employed and errors of the articulator. Errors during registration were attempted to be nullified by the use of protrusive jig and the use of silicon bite registration material. The main source of error could perhaps be attributed to the inherent limitations of the articulator used. In the cephalometric method, the plane of reference was the SN plane, whereas the facebow transfer is done with reference to the axis- orbital plane. Sella does not come into play during the facebow transfer. The angular deference between SN plane and FH plane is 7^{o}. This difference is accounted for by the compensatory mechanism of the Hanau™ Wide- Vue Articulator where the condylar horizontal axis is 7 mm below orbital index[28]. Semi adjustable articulator was used in the study for receiving the records from the clinical methods.[29]They are limited in their capabilities to accurately simulate the TMJs, the jaws, and their movements because of the fixed intercondylar distances and the straight condylar pathways, which are reported to cause errors, especially in the horizontal and frontal plane.

Therefore, it can be inferred that although a difference exists between the right and left condylar guidance values, the difference is insignificant. Several authors have reported a difference in the right and left condylar guidance values obtained using clinical methods, but such differences cannot be determined radiographically using lateral cephalogram which remains a limitation of this method.[30] However, radiographically, right and left CGA can be determined using computed tomography scans.

If further studies are to be carried on, then any random subjects can be selected: Skeletal Class I, Class II div 1, Class II div 2 and Class III unlike the present study in which only skeletal malocclusion is selection criteria for groups. In future, criteria such as growth pattern should be including in study. Clinical implication of the study is that in orthodontic diagnosis, it is important to recognize skeletal discrepancy between maxillary and mandibular apical bases as treatment planning aims at normalization of maxilla-mandibular relationship. Treatment plans and objectives are although not exclusively deeply driven by cephalometric information but in current diagnosis may lead to treatment planes which can be in adequate and treatment time may get extended. Clinician can take this as a guideline while planning & finishing the treatment in such a way that the rule of harmony is followed.

Conclusion

- Radiographic method showed greater value of CGA as compared to clinical method.
- In all four classes of patients, significant correlation between the radiographic and clinical method was found when protrusive method was used.
- Among the four skeletal classes, a significant difference was seen in the CGS values. In general, class II group yielded higher values and class III group had less steep condylar inclination as compared to class I group

- Average value of CGS should not used as wide variations in value exist among individuals with different skeletal relationships.
- No significant difference was noted between the right and left condylar inclination

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