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Research Article

Assessment of Condylar Height and Condylar Axis Angulation in Different Facial Types in Mixed Indian Population: A CBCT Study

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Abstract

Introduction: Condylar process is amongst the growth sites of mandible and may affect the magnitude and direction of growth of mandible. This study aims to assess the height of condyle and condylar axis angulation as exhibited by patients with different facial types, using a Cone Beam Computed Tomography (CBCT) imaging.

Material and Methods: A total of 90 patients' CBCT data was selected from the departmental archives for this study. The patients were divided into three vertical facial type groups based on the FMA angle with 30 patients in each facial type category. The condylar height and condylar axis angulation was measured in each facial type category and subjected to statistical analysis.

Result: The three groups did not differ in age and gender distribution. The mean condylar height in Group 1, Group 2 and Group 3 was 15.27 ± 1.25 mm, 14.99 ± 1.27 mm and 17.22 ± 1.15 mm respectively. The mean condylar axis angulation in Group 1, Group 2 and Group 3 was 61.57° ± 9.05°, 68.39o ± 4.02° and 56.23° ± 7.94° respectively. Distribution of mean condylar height was significantly higher in Group 3 compared to Groups 1 and 2 (P-value < 0.001). Distribution of mean condylar axis angulation was significantly higher in Group 2 compared to Groups 1 and 3 (P-value < 0.05).

Conclusion: This study concludes that the condylar height is greater in hyperdivergent facial type as compared to normo and hypodivergent types. Condylar axis angulation is larger in hypodivergent type as compared to normo and hyperdivergent types. It is recommended that similar studies with larger sample size be conducted which will enable the clinician to ascertain correct diagnosis and anticipate the treatment outcome in response to the growth pattern.

Keywords: *Condylar Height; Condylar Axis Angulation; Facial Type*

Introduction

Temporomandibular joint (TMJ) is a unique joint associated with the facial skeleton which has an influence over the growth and development of mandible in particular and face in general. Condylar process is amongst the growth sites of mandible. The direction and magnitude of growth of condyle may affect the direction and magnitude of growth of mandible and is a crucial factor for the variability in size, shape and function of mandible, TMJ and stomatognathic system [1]. The individual variation prevalent in nature is an outcome of variation in growth and development as a result of complex interaction between the various genetic and environmental factors [2].

Various attempts have been made in the literature to indentify these variations in size, shape and direction of growth of the condyle and the changes anticipated in the developing condyle, using variety of imaging techniques. This laborious exercise has resulted in knowledge regarding the different shapes and size of condyle and the pattern of remodelling that can be anticipated during the growth and development, but the plethora still remains unexplored. A considerable degree of variation is evident in facial type, proportions and pattern, which has been described by various authors under various classifications. One amongst the commonly followed classification of vertical facial type is the one which classifies the face as hypo-divergent, normo-divergent and hyper-divergent [3-5].

Various imaging modalities have been tested over years by various researchers and came to the conclusion that Cone Beam Computed Tomography (CBCT), can be considered as the current day gold standard imaging modality for orofacial structures [6]. The literature search reveals information about the variation in shape and size of condyle and its pattern of remodelling, however its association with different facial types and pattern of growth is still not clear. The study aims at assessment of condylar height and condylar axis angulation in different facial types in a mixed Indian population with objectives to establish co-relation between the facial types, condylar height and condylar axis angulation using CBCT, and also to determine the influence of gender and age of patient on the condylar height and condylar axis angulation.

Material and Method

A total of 90 patients' CBCT data (amongst patients who reported to the department for orthodontic treatment needs) was selected from the departmental archives as defined by the intrusion and extrusion criteria. Inclusion criteria included records of patients in Cervical Vertebrae Maturation Index (CVMI) stage VI, patients with no history of orthodontic treatment, complete set of medical and dental (pre-orthodontic treatment) records available. Exclusion criteria included patients with history of TMJ disorders, craniofacial trauma, craniofacial deformities or asymmetry, history of jaw surgery, malignancy or any other systemic disease, condition or syndrome affecting bone metabolism. The patient's data was further divided into three groups depending upon the Frankfort mandibular plane angle (FMA), with 30 patients in each vertical facial type group. Group 1 - Normodivergent facial type (FMA = 22° - 25°), Group 2 - Hypodivergent facial type (FMA < 22°) and Group 3 - Hyperdivergent facial type (FMA > 25°). The CBCT was recorded with New Tom Giano G-XR-46893 M/s Cefla Dental Group Italy, dental cone beam computed tomography machine using a standardised technique and exposure parameters with tube voltage of 60-90 KV, tube current 1 - 10 ma (pulsed mode), focal spot of 0.5mm and image resolution of 3.94 IP/mm. The Multiplanar reformation view (MPR) of CBCT data in sagittal view was used to assess the condylar height and condylar axis angulation. Measurement of the condylar height was done by constructing a tangent on the posterior border of mandible in sagittal view. A perpendicular was drawn to this tangent from the most cranial point on condyle and most caudal point of the mandibular notch (incisura mandibulae) (Figure 1). The distance between these two perpendiculars was considered as condylar height, similar to technique described by Kjellberg H., *et al* [7]. Condylar axis angulation was measured as the angle formed by the long axis of mandibular condyle and line parallel to the Frankfort horizontal plane in sagittal view (Figure 2). All the measurements on the 90 patient's CBCT data were carried out by author 1 and the same were reassessed by author 2 at one week interval. The results thus obtained were complied to check any inter-examiner variation and were subjected to statistical tests.

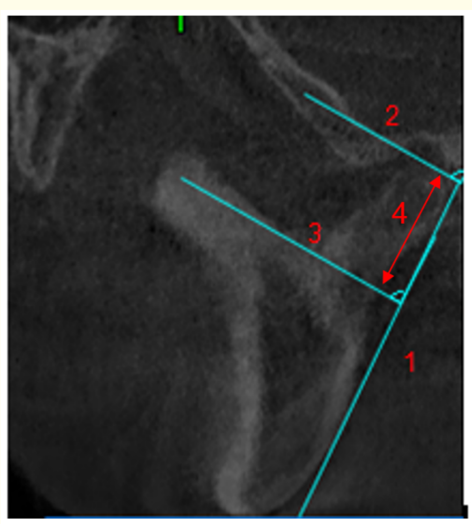

Figure 1: *Measurement of the mandibular condylar height (1- tangent on the posterior border of mandible in sagittal view, 2- perpendicular to the tangent from the most cranial point on condyle, 3- perpendicular to the tangent from most caudal point of the mandibular notch, 4- mandibular condylar height).*

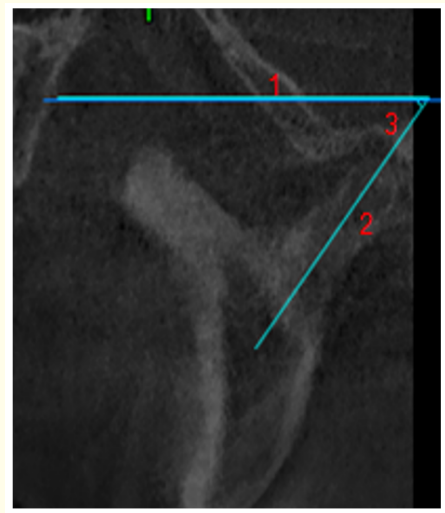

Figure 2: *Measurement of the condylar axis angulation (1- line parallel to FH plane, 2- long axis of condyle in sagittal view, 3- condylar axis angulation).*

Statistical analysis

The data on continuous variables is presented as mean and standard deviation (SD) and data on categorical variables is shown as n (% of cases) across three study groups. The inter-study group statistical comparison of means of continuous variables was done using analysis of variance (ANOVA) with Bonferroni's correction for multiple group comparisons. The inter-gender and inter-age group (two groups) statistical comparison of means of continuous variables was done using independent sample t test. The underlying normality assumption was tested before subjecting each variable to ANOVA and t test. In the entire study, the p-values less than 0.05 were considered to be statistically significant. All the hypotheses were formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data was statistically analyzed using Statistical Package for Social Sciences (SPSS ver 21.0, IBM Corporation, USA) for MS Windows.

Results

The inter-examiner recordings did not show any significant difference (kappa value = 0.8). The age distribution of cases studied did not differ significantly across three study groups (P-value > 0.05). The gender distribution of cases studied did not differ significantly across three study groups (P-value > 0.05).

Inter-group distribution of condylar height and condylar axis angulation

The distribution of mean ± SD of condylar height in Group 1, Group 2 and Group 3 was 15.27 ± 1.25 mm, 14.99 ± 1.27 mm and 17.22 ± 1.15 mm respectively. Distribution of mean condylar height was significantly higher in Group 3 compared to Groups 1 and 2 (P-value < 0.001 for both). Distribution of mean condylar height did not differ significantly between Group 1 and Group 2 (P-value > 0.05) (Table 1 and Figure 3). The distribution of mean ± SD of condylar axis angulation in Group 1, Group 2 and Group 3 was 61.57° ± 9.05°, 68.39° ± 4.02° and 56.23° ± 7.94° respectively. Distribution of mean condylar axis angulation was significantly higher in Group 2 compared to Groups 1 and 3 (P-value < 0.05). Distribution of mean condylar axis angulation did not differ significantly between Groups 1 and 3 (P-value > 0.05) (Table 1 and Figure 4).

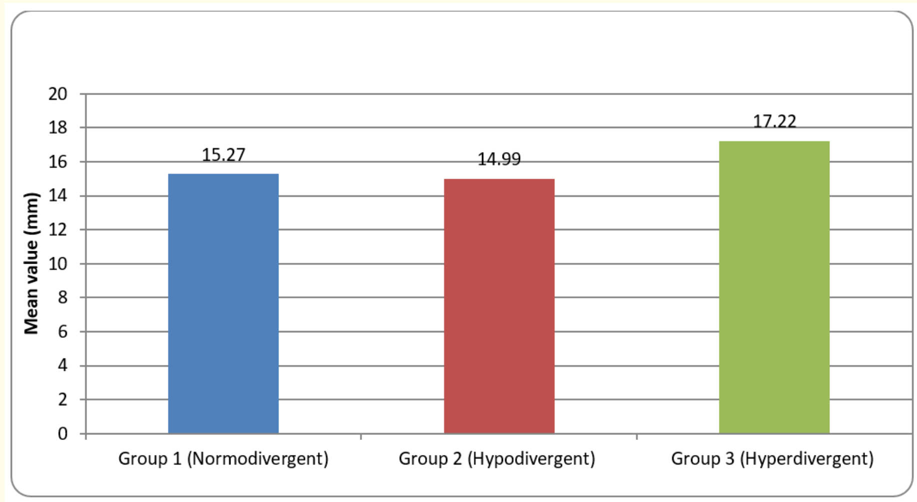

Figure 3: *Inter-group comparison of means of condylar height.*

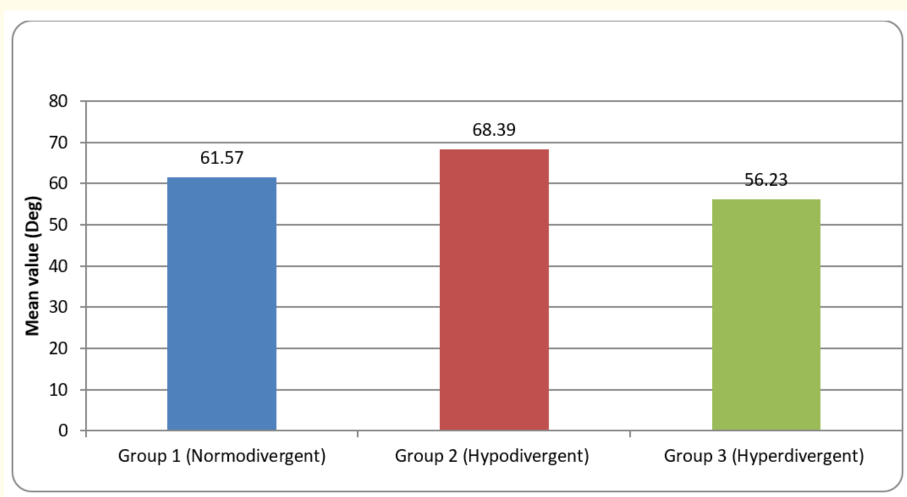

Figure 4: *Inter-group comparison of means of condylar axis angulation.*

	Group 1 (Normodivergent) (n = 30)		Group 2 (Hypodivergent) (n = 30)		Group 3 (Hyperdivergent) (n = 30)		P-value (Inter-Group)		
Measurements	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Group 1 v Group 2**	**Group 1 v Group 3**	**Group 2 v Group 3**
Condylar height (mm)	15.27	1.25	14.99	1.27	17.22	1.15	0.999^{NS}	0.001***	0.001***
Condylar axis angulation (Deg)	61.57	9.05	68.39	4.02	56.23	7.94	0.044*	0.157^{NS}	0.001***

Table 1: *Inter-group comparison of means of condylar height and condylar axis angulation.*
P-value by analysis of variance (ANOVA) with Bonferroni's correction for multiple group comparisons.
*P-value < 0.05 was considered to be statistically significant. *P-value < 0.05, **P-value < 0.01,*
****P-value < 0.001, NS-Statistically non-significant.*

Intra-group distribution of condylar height and condylar axis angulation

In normodivergent group the distribution of mean condylar height and mean condylar axis angulation did not differ significantly between males and females (P-value > 0.05 for both). Distribution of mean condylar height and mean condylar axis angulation did not differ significantly between group of cases with age less than 18 years and group of cases with age more than 18 years (P-value > 0.05 for both). In hypodivergent group the distribution of mean condylar height and mean condylar axis angulation did not differ significantly between males and females (P-value > 0.05 for both). Distribution of mean condylar height did not differ significantly between group of cases with age less than 18 years and group of cases with age more than 18 years (P-value > 0.05). Distribution of mean condylar axis angulation is significantly higher in the group of cases with age more than 18 years compared to group of cases with age less than 18 years (P-value < 0.05). In hyperdivergent group the distribution of mean condylar height and mean condylar axis angulation did not differ significantly between males and females (P-value > 0.05 for both). Distribution of mean condylar height and mean condylar axis angulation did not differ significantly between group of cases with age less than 18 years and group of cases with age more than 18 years (P-value > 0.05 for both) (Table 2, 3 and Figure 5-8).

	Group 1 (Normodivergent) (n = 30)			**Group 2 (Hypodivergent) (n = 30)**			**Group 3 (Hyperdivergent) (n = 30)**		
Measurements	**Male (n = 14)**	**Female (n = 16)**	**P-value**	**Male (n = 12)**	**Female (n = 18)**	**P-value**	**Male (n = 14)**	**Female (n = 18)**	**P-value**
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Condylar height (mm)	14.66 ± 0.56	15.80 ± 1.46	0.075[NS]	14.80 ± 1.15	15.12 ± 1.39	0.647[NS]	16.89 ± 0.88	17.51 ± 1.33	0.311[NS]
Condylar axis angulation (Deg)	57.97 ± 6.61	64.72 ± 10.11	0.156[NS]	67.82 ± 4.83	68.78 ± 3.65	0.667[NS]	57.21 ± 8.25	55.36 ± 8.11	0.669[NS]

Table 2: *Inter-gender group comparison of means of condylar height and condylar axis angulation.*
P-value by independent sample t test. P-value<0.05 was considered to be statistically significant. NS-Statistically non-significant.

	Group 1 (Normodivergent) (n = 30)			**Group 2 (Hypodivergent) (n = 30)**			**Group 3 (Hyperdivergent) (n = 30)**		
Measurements	**<18yrs (n = 18)**	**≥18yrs (n = 12)**	**P-value**	**<18yrs (n = 18)**	**≥18yrs (n = 12)**	**P-value**	**<18yrs (n = 16)**	**≥18yrs (n = 14)**	**P-value**
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Condylar height (mm)	15.43 ± 1.49	15.02 ± 0.83	0.546[NS]	14.54 ± 1.07	15.66 ± 1.33	0.097[NS]	17.20 ± 1.13	17.24 ± 1.27	0.946[NS]
Condylar axis angulation (Deg)	63.48 ± 10.50	58.72 ± 6.06	0.337[NS]	66.46 ± 3.94	71.30 ± 1.88	0.016*	53.65 ± 7.52	59.17 ± 7.87	0.188[NS]

Table 3: *Inter-age group comparison of means of condylar height and condylar axis angulation.*
P-value by independent sample t test. P-value<0.05 was considered to be statistically significant.
**P-value<0.05, NS-Statistically non-significant.*

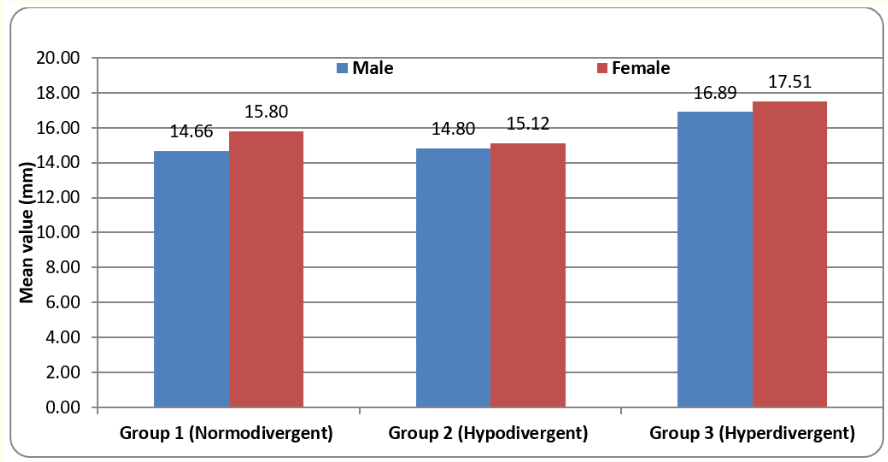

Figure 5: *Inter-gender group distribution of mean condylar height.*

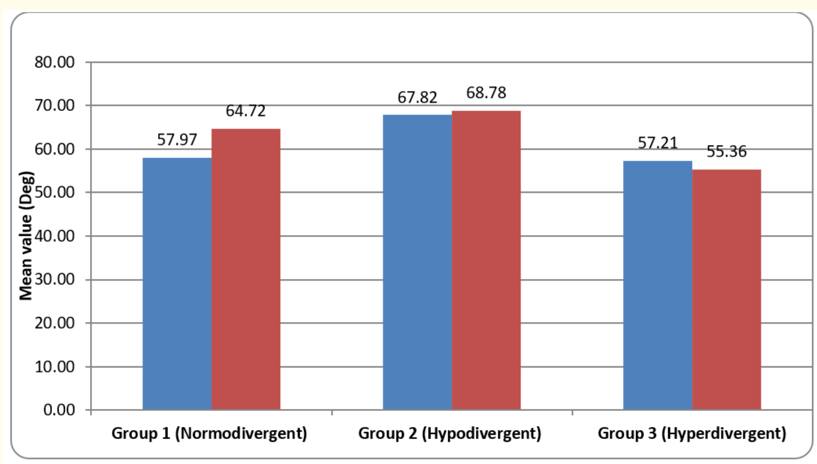

Figure 6: *Inter-gender group distribution of mean condylar axis angulation.*

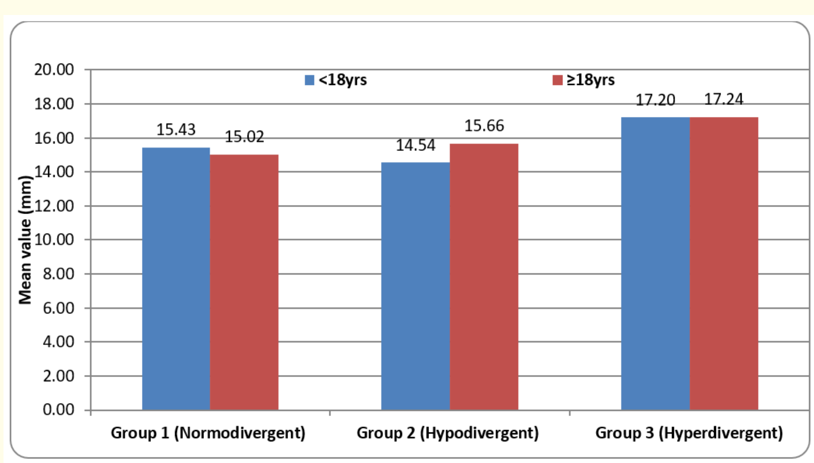

Figure 7: *Inter-age group distribution of mean condylar height.*

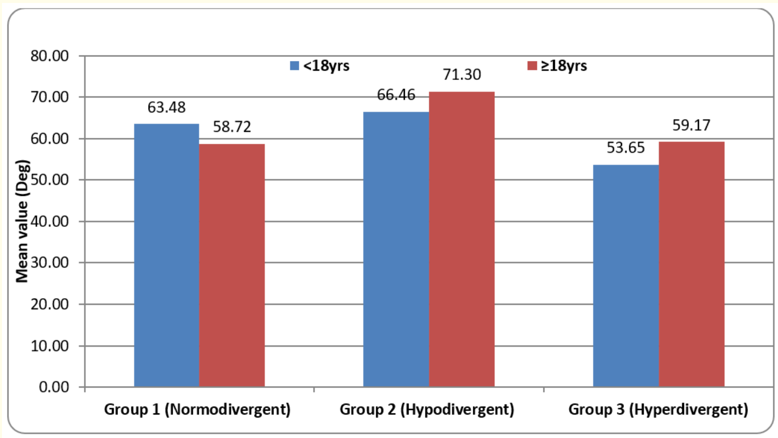

Figure 8: *Inter-age group distribution of mean condylar axis angulation.*

Discussion

Growth and development is an integral part of individual's life which is influenced by complex interaction between genetic and environmental factors. Condyle being the primary growth site has considerable influence on magnitude and direction of growth of mandible. Various authors such as Bjork [8], Profitt [9], Sugawara and Kawamura [4] have dwelled upon the role of condylar cartilage in mandibular growth and its influence on magnitude and direction of growth of mandible, making it a crucial factor for developing malformation or asymmetry. Itaru Mizoguchi [1] and co-workers reviewed the effect of condylar cartilage on development of mandible and stated its association with craniofacial morphogenesis and TMJ function. The condylar process grows in all directions from anterosuperior to posterior, resulting in highly variable mandibular growth and morphology. They concluded that condyle may play an important role in regulating rate of bone formation in intramembranous and endochondral ossification, resulting in variable growth directions and condylar and maxillofacial morphology. Hence, justifies the aim of our study that deliberates on assessing co-relation of condylar height with the various facial types and mandates the need to quantify this influence.

With the advent of time and developing technology, newer imaging techniques have been emerging to evaluate and visualise the hard tissues and their pattern of development. Thus, with the various available options, narrowing down to a best suitable option has always been a challenge. Goran Markic [10] and co-workers compared the various 2D and 3D imaging modalities to assess the length of the mandibular ramus and the condylar process and found that all 3D imaging procedures yielded nearly equal results when used to measure the condylar height and ramus height. They recommend MRI as it avoids ionizing radiation. The CBCT software also facilitates in true size digital measurements of the orofacial structures, thus providing ease of assessment of the obtained data. Our study used the CBCT which is proved to be current day gold standard for assessment of orofacial structures, which generates a more reliable 3D image with relatively less radiation exposure. Since, the sample includes data of patients reported to the department with orthodontic treatment needs, the CBCT was taken as a part of routine pre-treatment record. No additional radiation exposure to the patient was done for obtaining the data for our study.

Literature also reveals various methods introduced for assessment of condylar and ramal height in different imaging technique. Fuentes R [11] and co-workers assessed the reliability of Habet's technique and Kjellberg's technique [7] for recording the condylar height in an Orthopantomogram and found that both the methods provide acceptable clinical information within the limitations of these techniques to obtain data on condylar symmetries. The Kjellberg's technique [7] of determining condylar height was also used by Goran Markic [10] and co-workers in their study to compare various imaging modalities and the same was used in our study which describes the condylar height as measured between the most cranial point of the condyle and the most caudal point of the incisura mandibulae. Ricketts [5]and co-workers in their study have assessed the condylar axis angulation in relation to the mandibular body axis, however the current study co-relates the condylar axis to FH plane in sagittal plane. Mishra RK [12] and co-workers in their CBCT based study have evaluated the condylar position in skeletal class I and III growing individuals and have used condylar head axis in axial view in relation to the mid sagittal plane. However, present study takes into consideration the condylar axis in sagittal plane in relation to horizontal reference plane i.e. FH plane.

Extensive literature search fails to deliver similar work by other authors that would co-relate the facial types with condylar height and condylar axis angulation making our attempt a pioneer in this aspect. However, Mishra RK [12] and co-workers conducted a CBCT based study to evaluate condylar position in growing patients, in which they did not find significant difference in position of condyle in skeletal class I and class III individuals. The current study provides a significant relationship of condylar height with different facial type in which condylar height was observed to be greater in hyperdivergent type as compared to normo and hypodivergent types where as condylar axis angulation was observed to be larger in hypodivergent type as compared to normo and hyperdivergent types. However the current study fails to establishes a significant co-relation in respect to gender, in contradiction to the findings observed by Jyothsna M [13] and co-workers in their study of determining gender using condylar height, which stipulate higher values of condylar height in males and that the right condyle is more reliable for gender determination. Peter H Buschang [15] and co-workers gave co-relation between age and condylar height by proposing incremental growth chart. However, the co-relation of age and condylar height or condylar axis angulation could not be significantly established by the current study, probably owing to small sample size and wide range of age in different study groups.

Conclusion

The direction and magnitude of condylar growth may have influence over the magnitude and direction of mandible and orofacial structures and may play a crucial factor for developing dentofacial asymmetries and malformation. The assessment of the condylar height may give insight on the developing facial type and possible malformation. This study concludes that the condylar height is greater in hyperdivergent type as compared to normo and hypodivergent types. Condylar axis angulation is larger in hypodivergent type as compared to normo and hyperdivergent types. The mean condylar height and condylar axis angulation is observed to be larger in females as compared to males but is not statistically significant. In normodivergent group the mean condylar height and condylar axis angulation is larger in age group less than 18 yrs as compared to age group more than 18 yrs, while in hypodivergent and hyperdivergent groups the mean condylar height and condylar axis angulation is larger in age group more than 18 yrs. However, the co-relation of condylar height and condylar axis angulation with age is not statistically significant. It is therefore recommended that similar studies with more sample size be conducted for more realistic results to determine the co-relation of condylar height with different facial types, age and gender, which will enable the clinician to ascertain correct diagnosis with expected growth pattern to anticipate the probable treatment outcome in order to obtain a stable desired result.

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