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Original Research Article

Correlating condylar dimensions with growth pattern: A radiographic study

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ABSTRACT

Introduction: As lateral cephalograms are one of the mandatory pretreatment diagnostic radiographs for identifying the structural changes of the craniofacial skeleton including the mandibular condylar region, the present study attempts to evaluate the condylar dimensions in skeletal Class I cases with three different growth patterns using lateral cephalograms.

Aim and Objectives: This study aimed to evaluate the dimensions of the mandibular condyle and to determine any correlation with growth patterns in skeletal Class I patients.

Materials and Methods: This retrospective study was conducted on the lateral cephalogram of the patients reported for orthodontic treatment. After applying inclusion and exclusion criteria 60 lateral cephalograms were selected and distributed in three groups. The measurements of condylar neck length, condylar neck inclination, condylar width, and ramal length were measured on lateral cephalograms.

Result: The mean condylar dimensions were 12.18 ±1.44 mm of condylar width, condylar neck length of 16.82 ± 3.23 mm, and condylar inclination of 114.43° ± 13.98°. The differences in condylar width among the three groups were not statistically significant. Pearson correlation reveals a statistically highly significant positive correlation between condylar neck length and ramal length. The condylar inclination was negatively correlated with the condylar neck length and ramal length but was not statistically significant.

Conclusion: Within the scope of this study, it can be concluded that condylar width does not have a significant correlation with growth patterns. With the increase in condylar neck length, the overall ramal length also increases. There exists a negative correlation of condylar inclination with ramal length and condylar neck length but it was statistically not significant.

1. Introduction

Many researchers in the previous century explained the growth of the mandible to its full potential under the influence of its inherent genotypic expression or environmental influences.[1–8] Bjork A with his implant studies could able to explain the types of rotations occurring in the mandible and their manifestations on the overall development of the face.[9] He further elucidated the vertical and horizontal growth patterns based on the rotational center and explained various structural changes in the mandibular condylar region with respect to these growth patterns, which may be manifested as changes in the condylar inclination, condylar length, etc.

Since the introduction of Andersen's activator, many theories and appliances have evolved over a period of one century explaining the growth of the craniofacial skeleton including the condylar region. Research over a period of a few decades explained the natural growth of the mandibular condyles and the role of orthopaedic appliances in altering the growth changes.[10–15]

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The morphological changes developing in the condylar head and neck region due to growth or under the influence of orthopedic appliances ultimately decide the growth pattern and facial forms. Hence, any gross differences in the condylar region of one side compared to its contralateral side may result in facial asymmetry. The measurement of this asymmetry on orthopantomogram and the development of an asymmetric index had been attempted by a few authors in the late 20^{th} century.[16] With the advent of better radiographic diagnostic aids, the precise assessment of condylar morphology could have been possible. Although the measurement of quantum of asymmetry through CBCT or any other prescribed asymmetric indices is possible, to date no norms of condylar dimensions were ever established for Indian populations which could be used as a basic guide for precisely diagnosing the condyle at fault for causing facial asymmetry except for gross craniofacial anomalies. Therefore, the present study aims to the measurement of condylar dimensions in skeletal Class I cases with a wide range of growth patterns in the mixed Indian population.

As lateral cephalograms are one of the mandatory pretreatment diagnostic radiographs and an efficient tool to identify the structural changes of the craniofacial skeleton including the mandibular condylar region, the present study attempts to evaluate the condylar dimensions in skeletal Class I cases with three different growth patterns using lateral cephalograms. The measured values were correlated with each other with respect to various growth patterns in vertical dimensions.

2. Aim and Objectives

The aim of this study is to evaluate the dimensions of the mandibular condyle and to determine any correlation of various growth patterns in skeletal Class I individuals with condylar neck dimensions and ramal length.

3. Materials and Methods

This retrospective study was conducted on the lateral cephalogram of the patients who visited the Orthodontic department of a tertiary care Government hospital for routine orthodontic treatment. Lateral cephalograms of the patients were collected from the departmental archives from Jan 2018 to Jul 2022 and the following inclusion and exclusion criteria were made for the selection of the study sample.

3.1. Inclusion criteria

1. Skeletal Class I patients with ANB 2-4°
2. Both the genders included
3. Patients age >18 yrs, CVMI stage V/VI
4. Patients with complete pre-treatment records (including medical case sheet)
5. Patients in permanent dentition without any missing tooth (except 3^{rd} molars)

3.2. Exclusion criteria

1. Patients with mandibular asymmetry as diagnosed clinically & radiographically
2. Syndromic patients with craniofacial anomalies including Cleft lip & palate
3. Patients with a history of trauma in the maxillofacial region
4. Patients with a history of pathology causing deformation of the craniofacial region
5. Patients with a history of maxillary or mandibular surgery
6. Patients with a history of hormonal & nutritional imbalances influencing the growth and development of the craniofacial region or bone metabolism
7. Patients with a history of orthodontic/orthopedic treatment

After applying the inclusion and exclusion criteria, 84 cases were selected, divided into three groups based on the patient's growth pattern. Among these 84 cases, 30 were Normodivergent, 28 were Hypodivergent and 26 were Hyperdivergent. The criteria for grouping the cases depended upon the mandibular plane angle as measured between the Sella Nasion plane (SN) and a line connecting Gonion and Gnathion (GoGn). Group 1 had SN to GoGn < 27° (Hypodivergent); Group 2 had SN to GoGn between 27-32° (Normodivergent) and Group 3 had SN to GoGn >32° (Hyperdivergent).

All the radiographs were examined by an orthodontist with adequate clinical experience. Eighteen case records didn't have the soft copy of the radiographs and the hard copy prints were not clear enough for the identification of the landmarks. Additional six cases comprising one hypodivergent and five normodivergent did not have the complete medical case sheet available. Finally, 60 lateral cephalograms comprising 20 each in all three groups were collected for further measurements and analysis. As all the lateral cephalograms were recorded on a single machine (*New Tom Giano G-XR 46893*), radiographic projection errors were eliminated. However, the measurements were repeated again by the same observer over a period of one week and the kappa coefficient was applied for evaluation of intra-observer bias.

The landmarks and planes being used for the measurements on lateral cephalograms were as follows:

For Condylar neck dimensions-

1. Anterior most point of the condylar head (Ap)
2. Posterior most point of the condylar head (Pp)
3. Deepest point on the sigmoid notch of the mandible (Ds)

Table 1: Means and standard deviations of the parameters being measured

Parameters	Growth pattern	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Condylar width (CW)	Hypodivergent	20	12.250	1.5432	0.3451	11.528	12.972
	Normodivergent	20	12.000	1.1121	0.2487	11.480	12.520
	Hyperdivergent	20	12.300	1.6812	0.3759	11.513	13.087
	Total	60	12.183	1.4467	0.1868	11.810	12.557
Condylar Neck Length (CNL)	Hypodivergent	20	17.75	3.754	0.839	15.99	19.51
	Normodivergent	20	17.90	2.511	0.561	16.72	19.08
	Hyperdivergent	20	14.80	2.397	0.536	13.68	15.92
	Total	60	16.82	3.239	0.418	15.98	17.65
Ramal Length (RL)	Hypodivergent	20	55.80	6.856	1.533	52.59	59.01
	Normodivergent	20	51.35	3.438	0.769	49.74	52.96
	Hyperdivergent	20	48.75	4.518	1.010	46.64	50.86
	Total	60	51.97	5.842	0.754	50.46	53.48
Condylar inclination (CI)	Hypodivergent	20	110.90	15.022	3.359	103.87	117.93
	Normodivergent	20	107.95	9.806	2.193	103.36	112.54
	Hyperdivergent	20	124.45	11.081	2.478	119.26	129.64
	Total	60	114.43	13.988	1.806	110.82	118.05

Table 2: Comparisons of the measured parameters within and between the groups

		Sum of Squares	df	Mean Square	F	Sig.
CW	Between Groups	1.033	2	0.517	0.241	0.787
	Within Groups	122.450	57	2.148		
	Total	123.483	59			
CNL	Between Groups	122.233	2	61.117	7.013	.002
	Within Groups	496.750	57	8.715		
	Total	618.983	59			
RL	Between Groups	508.433	2	254.217	9.625	<.001
	Within Groups	1505.500	57	26.412		
	Total	2013.933	59			
CI	Between Groups	3097.033	2	1548.517	10.448	<.001
	Within Groups	8447.700	57	148.205		
	Total	11544.733	59			

Table 3: Correlation of the measured parameters between the groups

		CW	CNL	RL	CI
CW	Pearson Correlation	1	0.033	-0.041	0.066
	Sig. (2-tailed)		0.805	0.754	0.614
	N	60	60	60	60
CNL	Pearson Correlation	0.033	1	0.681**	-0.156
	Sig. (2-tailed)	0.805		<.001	0.235
	N	60	60	60	60
RL	Pearson Correlation	-0.041	0.681**	1	-0.201
	Sig. (2-tailed)	0.754	<.001		0.124
	N	60	60	60	60
CI	Pearson Correlation	0.066	-0.156	-0.201	1
	Sig. (2-tailed)	0.614	0.235	0.124	
	N	60	60	60	60

4. Co: Condylion
5. Go: Gonion

The planes being used are as follows-

1. FH Plane: (Po to Orbitale)
2. HP: (Horizontal line drawn tangent to the Ds and parallel to FH plane
3. CW: (Line joining Ap and Pp)
4. CNL: Condylar neck length (line drawn from Co to Ds bisecting CW)
5. CI: Condylar neck inclination (Anterosuperior angle formed between CNL and HP)
6. RL: Ramal length (line between Co to Go)

3.3. Statistical evaluation

The measurements were compiled and statistical evaluation was done on SPSS 26 version. The homogeneity of variances was evaluated with Levene statistical test. The mean values with a standard deviation of all the parameters are shown in Table 1. One-way ANOVA was applied for comparing the means between the groups with a confidence interval of 95% and a level of significance of mean difference at 0.05 (Table 2). Post hoc test was applied for multiple comparisons of means between and within the groups. Pearson correlation was done for evaluating any significant correlation between various parameters between the groups (Table 3).

4. Results

The mean condylar dimensions were 12.18 ±1.44 mm of condylar width, condylar neck length of 16.82 ± 3.23 mm, and condylar inclination of 114.43° ± 13.98°. Statistically, there were highly significant differences in the ramal length and condylar inclination among all three groups with a p-value < 0.001. The differences in condylar neck length among the groups were significant with a p-value of 0.002. The differences in condylar width among the three groups were not significant. Pearson correlation reveals a statistically highly significant positive correlation between condylar neck length and ramal length with a p-value <0.001. Although the condylar inclination was negatively correlated with the condylar neck length and ramal length, it was not statistically significant.

5. Discussion

The variations in the morphological pattern of the mandibular condyle may be influenced by age, gender, ethnicity, facial type, occlusal force, functional load, and malocclusion, and these variations can also be seen even between the right and left sides.[17,18] Yale SH et al. extensively studied the human jaws from a large collection of human skeletons and could able to classify the mandibular condyle into four basic types.[19] However, Mongini F had further elaborated on the shapes of mandibular condyle based on his studies on 100 dry crania of males and females and categorized them into eight types of condylar shapes.[20] Oh MH et al. described the 3D morphological changes through CT scan and emphasized that in individuals with facial asymmetry, the deviation of the menton is associated with the right/left differences caused by a smaller condyle on the deviated side, particularly in neck length and neck and head volumes.[21]

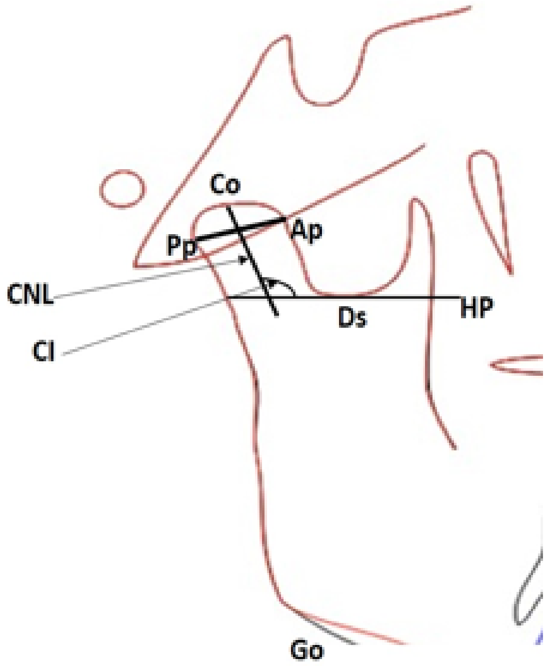

Figure 1: Schematic diagram showing the reference planes and measurements

The present study collected the data of a mixed Indian urban population for the measurement of the various condylar dimensions in lateral cephalograms of patients with skeletal Class I bases with different growth patterns. Although CBCT is considered the gold standard for most of the measurements of the craniofacial skeleton, the occurrence of increased radiation exposure compared to conventional lateral cephalograms restricts the use of CBCT. Further, few researchers attempted to ascertain the condylar morphological variations among different malocclusions through Cone Beam Computed Tomography (CBCT) and concluded that there exists a clear correlation between extreme skeletal patterns and condylar characteristics in the adult sample.[21]

The mean condylar dimensions recorded in this study were 12.18 ±1.44 mm of condylar width, condylar neck length of 16.82 ± 3.23 mm, and condylar inclination of 114.43° ± 13.98°. The statistical evaluation for comparison of means of three vertical groups reveals statistically highly significant differences in the ramal length and condylar inclination with a *p-value* < 0.001 and for condylar neck length, the differences were significant with a p-value of 0.002. The differences in condylar width in the three groups were not significant. Pearson correlation between the three vertical groups reveals a statistically highly significant positive correlation between condylar neck length and ramal length with a p-value <0.001. Although the condylar inclination was negatively correlated with the condylar neck length and ramal length, it was not statistically significant.

Although Bjork[9] has explained various structural signs in the condylar neck and ramus of the mandible, its applicability in all populations and ethnic groups cannot be confirmed. Further, a significant correlation of neck inclination with backward or forward rotations of the mandible could not be confirmed by the present study.

The present study primarily focussed only on the patients with skeletal Class I bases to ascertain the correlation of various condylar parameters with varying vertical dimensions, keeping the horizontal and transverse dimensions within normal range. This is for the sake of setting up ideal norms for a defined mixed Indian population. The further emphasis of the authors will be to correlate the same parameters with skeletal malocclusion in all three planes.

6. Conclusion

The mean values of condylar dimensions can be utilized to precisely diagnose the etiology of the mandibular asymmetry, especially in patients with skeletal Class I bases. Further, within the scope of this study, we can conclude that:

1. Condylar width does not have a significant correlation with the growth pattern
2. With the increase in condylar neck length the overall ramal length also increases
3. There exists a negative correlation of condylar inclination with ramal length and condylar neck length but it is statistically not significant.

Further evaluation of condylar dimensions for patients with Class II and III skeletal bases is required for the Indian population from different geographical belts to better evaluate and diagnose the patient based on his ethnicity.

7. Source of Funding

None.

8. Conflict of Interest

None.

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