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A Comparative Evaluation of Antegonial Notch Depth, Symphysis Morphology, Ramus and Mandibular Morphology in Different Growth Patterns in Angle's Class I Malocclusion: A Cross-Sectional Retrospective Lateral Cephalometric Study in Contemporary Indian Population

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ABSTRACT

Introduction: Growth and development has always remained the topic of interest for various researchers as it has a direct effect on the orthodontic diagnosis and treatment planning. A reliable method for growth prediction would be a key asset to the orthodontist. The depth of antegonial notch and mandibular morphology are important indicators of growth pattern. **Materials and methods:** The sample included 80 lateral cephalograms with Angle's class I malocclusion; ANB=2–4°, aged 18-30 years. The adults were categorized as average growers (GO-GN to SN = 28–34°), horizontal growers (GO-GN to SN = <28°) and vertical growers (GO-GN to SN = >34°). The antegonial notch depth, symphysis height, symphysis depth, ratio (height of symphysis/depth of symphysis), angulation of symphysis, inclination of symphysis, ramus height, ramus width, mandibular and body length were assessed**.** To evaluate statistical significance for each parameter amongst all the three groups, one way ANOVA test was applied. **Results:** A comparative evaluation revealed statistically significant difference with antegonial notch depth, symphysis height, symphysis depth, ratio (height of symphysis/depth of symphysis), angulation of symphysis, inclination of symphysis, ramus height and ramus width. **Conclusion:** Antegonial notch depth is greater in the vertical growers as compared to horizontal and average growers. Symphysis morphology in horizontal growth pattern is associated with short height, large depth, small ratio (height/depth), and larger angle. Conversely, symphysis with a larger height, smaller depth, larger ratio, and a smaller angle is found in vertical growers. Ramus height and width is greater in horizontal growers as compared to the vertical growers.

KEYWORDS: *antegonial notch, average growth pattern, horizontal growth pattern, vertical growth pattern, ramus morphology, symphysis morphology and mandibular morphology*

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INTRODUCTION

Growth and development has always remained the topic of interest for various researchers as it has a direct effect on the orthodontic diagnosis and treatment planning. A reliable method for growth prediction would be a key asset to the orthodontist. Early intervention to correct underlying skeletal discrepancies can be done by orthopedic intervention. Growth modification procedures can be successfully applied if one can predict the nature, magnitude and direction of mandibular growth. Prediction of growth of the entire face is most desirable but accurate prediction of mandibular growth would be of great benefit. This idea has inspired previous investigators to assess a variety of methods to predict mandibular growth.

Various authors like Maj and Luzi[1], Skieller et al[2], Lee et al[3] and Leslie et al[4], Huggare[5], Solow and Siersbæk-Nielsen[6], Huggare and Cooke[7], Halazonetis et al[8], Rossouw et al[9] and Aki et al[10] have conducted studies on mandibular growth with reasonable amount of success. Authors like Singer CP[11] and Lambrechts[12] AHD have explored the possibility that mandibular antegonial notch morphology might predict mandibular growth. These studies were based on the findings of Bjork[13,14], who reported that mandibles with a forward growth tendency exhibit a pattern of surface apposition below the symphysis and surface resorption under the mandibular angle. In persons with a backward mandibular growth tendency the opposite pattern occurred, leading to concavity on the inferior border of the mandible known as the antegonial notch.

The primary reference for esthetic considerations in lower one-third of the face as well as the predictor for the direction of mandibular growth rotation is the mandibular symphysis. In a study conducted by Rickets a thick symphysis is associated with an anterior growth direction. It's morphology results from an interplay of various factors that can be genetic, nongenetic, or the adaptive factors. The shape during the growth period may indirectly be affected by the inclination of lower incisors, and dentoalveolar compensation occurring during that period as a result of anteroposterior (AP) jaw discrepancy which might be reflected in the morphology and dimension of the symphysis[15]. Also, the variables such as the symphysis depth, symphysis height, symphysis ratio, symphysis angle, and symphysis inclination to the mandibular plane are associated with the growth pattern of an individual.

An important consideration in evaluation of a specific treatment plan for an individual is the mandibular symphysis size and shape. If the symphysis is large, it is esthetically acceptable to leave the incisors slightly proclined, and thus, we can opt for a nonextraction plan to compensate for tooth size arch length discrepancies, whereas in patients with small chin and the same arch length discrepancies, proclined incisors would be unaesthetic, and thus we opt for an extraction treatment plan[16]. The inclination of symphysis is also an important feature. As stated by Björk, in vertical growth pattern or hyperdivergent cases, the chin is prominent and the symphysis swings forward, whereas in cases of horizontal or hypodivergent cases, a receding chin is seen with the symphysis swung back.

Prediction of growth pattern by the morphology of the mandible has clinical implications in treatment planning for the patient as the extraction decision, type of anchorage preparation, mechanics, and retention period are influenced by the growth pattern of an individual.

Although various cephalometric parameters have been used to describe mandibular morphology, very few studies have reported comparison and correlation in different growth patterns in Angle's class I malocclusion. Thus, the purpose of this study was to compare and correlate between antegonial notch depth, symphysis morphology, ramus and mandibular morphology in different growth patterns in Angle's Class I malocclusion.

OBJECTIVES

1. To evaluate antegonial notch depth, symphysis morphology, ramus and mandibular morphology in average growth pattern in Angle's class I malocclusion.
2. To evaluate antegonial notch depth, symphysis morphology, ramus and mandibular morphology in horizontal growth pattern in Angle's class I malocclusion.
3. To evaluate antegonial notch depth, symphysis morphology, ramus and mandibular morphology in vertical growth pattern in Angle's class I malocclusion.
4. To compare antegonial notch depth, symphysis morphology, ramus and mandibular morphology in average, horizontal and vertical growth patterns in Angle's class I malocclusion.

MATERIALS AND METHODS

Pretreatment lateral cephalometric radiographs of 80 adult patients (35 males, 45 females) for this investigation were obtained from the records of patients that reported to MGV's KBH dental college and hospital in the department of orthodontics and dentofacial orthopaedics meeting the inclusion criteria of the study. A power analysis was established by G*Power, version 3.0.10 (Franz Faul Universita¨t, Kiel, Germany); based on a 1:1 ratio between groups, a sample size of 80 lateral cephalograms would yield more than 80% power to detect significant differences at (alpha) =0.05 significance level.

Inclusion criteria:

1. Angle's Class I malocclusion with angle ANB 2-4 deg.
2. Age group 18-30 years; both males and females.
3. Intact permanent dentition with or without third molars.
4. No history of orthodontic treatment and/or functional orthopedic treatment.
5. Standardized lateral cephalogram with adequate sharpness and resolution.

Exclusion criteria:

1. Angle Class II or III malocclusion.
2. Mixed/deciduous dentition.
3. Grossly decayed teeth or extensive carious lesion.
4. Patients with congenital anomalies and trauma.
5. Facial asymmetry and syndromes.
6. TMJ or cervical spine disorders.

All the lateral cephalograms were traced by the same operator on an acetate sheet of 0.5 mm thickness with a 0.50-mm mechanical pencil. All the landmarks were identified and marked (Table 1 and Figure 1). To determine the growth pattern of the adults, GO-GN to SN was used. All the 80 adults were grouped into three categories as average growers (GO-GN to SN = 28–34°), horizontal growers (GO-GN to SN = <28°) and vertical growers (GO-GN to SN = >34°).

All these three groups were evaluated to study the antegonial notch depth, symphysis morphology, ramus and mandibular morphology.

Sella (S)	Midpoint of sella turcica.
Nasion (N)	Junction of the nasal and frontal bones at the naso-frontal suture.
Orbitale	Most inferior point on the infra-orbital margin
A-point	Point of deepest concavity of the anterior maxilla between the anterior nasal spine and the alveolar crest
B-point	Point of deepest concavity of the anterior mandible between the alveolar crest and pogonion
Pogonion (Pg)	Most anterior point on the anterior outline of the symphysis
Gnathion (Gn)	Midpoint along the contour of the anterior outline of the symphysis between pogonion and menton
Menton (Me)	Most inferior point on the inferior outline of the symphysis

Anterior Convexity Point (ACP)	Point of greatest convexity along the anterior-inferior border of the mandible.
Antegonial Notch	Point of deepest concavity between anterior convexity point and inferior gonion
Inferior Gonion (IGo)	Point of greatest convexity along the posterior-inferior border of the mandible
Machine Porion	Most superior point of radiographic image of ear rod
Porion	Most superior point of external auditory meatus

Table 1: Definitions of skeletal landmarks identified on cephalograms

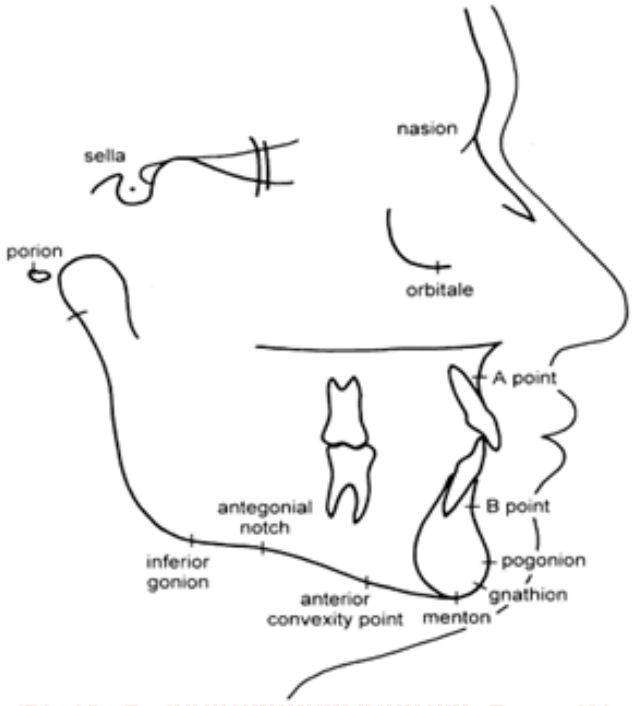

Figure 1: Representative cephalometric landmarks.

Calculation of Depth of Antegonial Notch: Antegonial notch is a concavity on the inferior border of the mandible. Two points traced on the mandible were anterior convexity point (ACP) and inferior gonion (IGo), where ACP is the point of greatest convexity along the anterior-inferior border of the mandible and IGo is the point of greatest convexity along the posterior-inferior border of the mandible. A line was drawn joining these two reference points. Antegonial notch depth is the greatest point of convexity in antegonial notch area in the lower border of mandible (Figure 2).

Figure 2: Antegonial notch depth is the greatest point of convexity in antegonial notch area in the lower border of mandible.

Cephalometric Evaluation of Symphysis:

A. Calculation Symphysis Dimensions: A line tangent to point B was taken as the long axis of the symphysis. A grid was formed with lines of grid parallel and perpendicular to constructed tangent line. Superior limit of symphysis was taken as point B with inferior, anterior, and posterior limits taken at most inferior, anterior, and posterior borders of symphyseal outline, respectively.

1. **Symphysis height** is defined as the distance from the superior to the inferior limit on the grid (Figure 3).
2. **Symphysis depth** is defined as the distance from the anterior to the posterior limit on the grid (Figure 3).

3. **Symphysis ratio** is calculated by dividing the symphysis height by symphysis depth.
4. **Symphysis angle** is determined by the posterior-superior angle formed by the line through Menton and point B and the mandibular plane (Go-Me) (Figure 3).

B. Inclination of Symphysis:

Inclination of symphysis in relation to mandibular plane was measured. The angle between a line connecting point B to pogonion and mandibular plane reflects the inclination of the skeletal part of the mandibular symphysis in relation to the mandibular plane (Figure 3).

Ramus morphology:

1. **Ramus height** – the linear distance between Articulare and Gonion (Figure 3).
2. **Ramus width** – the linear distance measured at the height of the occlusal plane between anterior and posterior border of ramus of the mandible (Figure 3).

Mandibular morphology:

1. **Mandibular length:** the linear distance between condylon and Gnathion (Co-Gn) (Figure 3).
2. **Body morphology:** the linear distance between Gonion and Menton (Go-Me) (Figure 3).

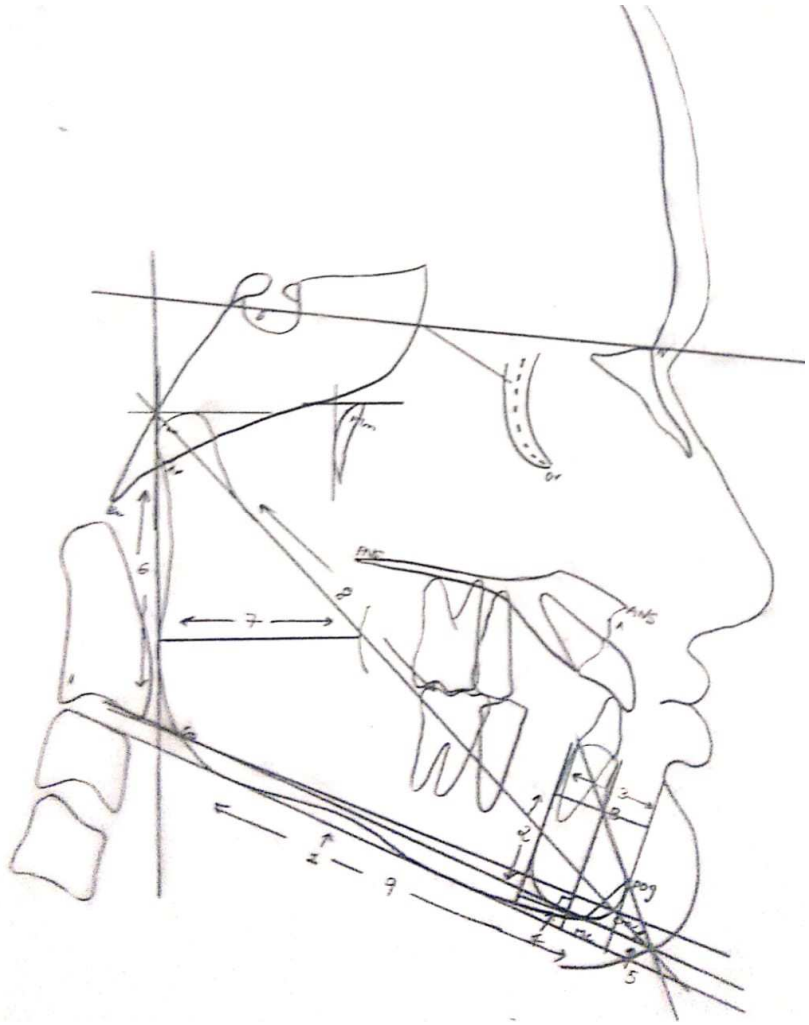

Figure 3- 1-antegonial notch, 2-symphysis height, 3-symphysis depth, 4-symphysis angle, 5-inclination of symphysis, 6-ramus height, 7-ramus width, 8-mandibular length and 9-body length.

STATISTICAL ANALYSIS

Mean and standard deviation of each variable were calculated. One-way analysis of variance (ANOVA) was performed to determine whether there was a difference between the three groups for each of these variables, and it was followed by a post hoc test in which a *p* value < 0.05 was considered significant. The analysis was performed using IBM SPSS software (version 18.0, Armonk, NY).

RESULTS

The lateral cephalograms of total 80 patients that are divided into three groups were studied and analyzed. The descriptive statistics which is the mean, standard deviation, and the errors of the difference between mean and levels of significance of all the 10 variables were studied for the three groups (average, horizontal and vertical growers) are summarized in Table 2. The one-way ANOVA results applied to the study groups and the post hoc multiple comparisons Bonferroni results are shown in Table 3.

Variables	Groups I–III	Mean ± SD	Standard error
Antegonial notch width (mm)	Group I (Average)	0.71±0.90	0.15
	Group II (Horizontal)	0.35±0.60	0.11
	Group III (Vertical)	1.59±1.15	0.28
Symphysis height (mm)	Group I (Average)	19.75±3.2	0.60
	Group II (Horizontal)	20.3±2.80	0.51
	Group III (Vertical)	20.06±3.37	0.84
Symphysis depth (mm)	Group I (Average)	15.17±3.09	0.52
	Group II (Horizontal)	15.33±1.98	0.36
	Group III (Vertical)	14.93±1.28	0.32
Ratio	Group I (Average)	1.26±0.18	0.03
	Group II (Horizontal)	1.35±0.24	0.04
	Group III (Vertical)	1.34±0.23	0.05
Angulation of symphysis (degrees)	Group I (Average)	88.34±3.98	0.66
	Group II (Horizontal)	89.16±6.53	1.19
	Group III (Vertical)	85.62±5.05	1.26
Inclination of symphysis (degrees)	Group I (Average)	60.37±8.22	1.39
	Group II (Horizontal)	66.3±6.73	1.23
	Group III (Vertical)	63.06±5.18	1.29
Ramus height	Group I (Average)	46.88±4.93	0.83
	Group II (Horizontal)	50±7.13	1.30
	Group III (Vertical)	43.12±5.71	1.42
Ramus width	Group I (Average)	28.05±4.02	0.68
	Group II (Horizontal)	29.4±0.76	0.76
	Group III (Vertical)	26.18±3.25	0.81
Mandibular length	Group I (Average)	112.77±8.63	1.45
	Group II (Horizontal)	113.1±9.52	1.73
	Group III (Vertical)	109.75±9.73	2.43
Body length	Group I (Average)	68.11±8.10	1.36
	Group II (Horizontal)	70.6±6.44	1.17
	Group III (Vertical)	65.87±5.77	1.44

Table 2- Descriptive analysis (mean, SD, and standard error)

Variables		Mean difference	P value
Antegonial notch width (mm)	Average vs horizontal	0.36	P>0.05
	Average vs vertical	-0.87	P<0.01
	Horizontal vs vertical	-1.24	P<0.001
Symphysis height (mm)	Average vs horizontal	-0.54	P>0.05
	Average vs vertical	-0.30	P>0.05
	Horizontal vs vertical	0.23	P<0.01
Symphysis depth (mm)	Average vs horizontal	-0.16	P>0.05
	Average vs vertical	0.23	P>0.05
	Horizontal vs vertical	0.39	P<0.01
Ratio	Average vs horizontal	-0.09	P>0.05
	Average vs vertical	-0.08	P>0.05
	Horizontal vs vertical	0.009	P<0.01
Angulation of symphysis (degrees)	Average vs horizontal	-0.82	P>0.05
	Average vs vertical	2.71	P>0.05
	Horizontal vs vertical	3.54	P<0.01
Inclination of symphysis (degrees)	Average vs horizontal	-5.92	P<0.01
	Average vs vertical	-2.69	P>0.05
	Horizontal vs vertical	3.23	P>0.05
Ramus height	Average vs horizontal	-3.11	P>0.05
	Average vs vertical	3.76	P>0.05
	Horizontal vs vertical	6.87	P<0.01
Ramus width	Average vs horizontal	-1.34	P>0.05
	Average vs vertical	1.87	P>0.05
	Horizontal vs vertical	3.21	P<0.05
Mandibular length	Average vs horizontal	-0.32	P>0.05
	Average vs vertical	3.02	P>0.05
	Horizontal vs vertical	3.35	P>0.05
Body length	Average vs horizontal	-2.48	P>0.05
	Average vs vertical	2.23	P>0.05
	Horizontal vs vertical	4.72	P>0.05

Table 3- One-way analysis of variance (ANOVA) and the post hoc multiple comparisons Bonferroni

1. **Depth of the Antegonial Notch:** The mean values for depth of the antegonial notch were greatest for the vertical group with a mean value of 1.59 mm ± 1.15, followed by the average group with a mean value of 0.71 mm ± 0.90 and then the horizontal group with a mean value of 0.35 mm ± 0.60. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference with horizontal and average groups with a *p* value of 0.001 and 0.01 (< 0.05) for both the groups respectively.
2. **Height of the Symphysis:** The mean values for the symphysis height were greatest for the horizontal group with a mean value of 20.3 mm ± 2.80, followed by the vertical group with a mean value of 20.06 mm ± 3.37and then the average group with a mean value of 19.75 mm ± 3.2. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
3. **Depth of the Symphysis:** The mean values for the symphysis depth were greatest for the horizontal group with a mean value of 15.33 mm± 1.98 followed by average group with a mean value of 15.17 mm ±3 .09 and then the vertical group with a mean value of 14.93 mm ± 1.28. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
4. **Ratio of the Height and Depth of the Symphysis:** The mean values for ratio of the height and depth of the symphysis were greatest for the horizontal group with mean value of 1.35 mm ± 0.24, followed by the vertical group with a mean value of 1.34 mm ± 0.23 and then the average group with a mean value of 1.26 mm ± 0.18. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
5. **Angulation of the Symphysis:** The mean values for angulation of the symphysis were greatest for the horizontal group with a mean value of 89.16 mm ± 6.53 degrees followed by average group with a mean value of 88.34 mm ± 3.98 degrees and then the vertical group with a mean value of 85.62 mm ± 5.05 degrees. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
6. **Inclination of the Symphysis:** The mean values for the symphysis inclination were greatest for the horizontal group with a mean value of 66.3 mm ± 6.73 degrees followed by vertical group with a mean value of 63.06 mm ± 5.18 degrees and then the average group with a mean value of 60.37 mm ± 8.22 degrees. The post hoc multiple comparisons Bonferroni test results revealed that the average group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
7. **Ramus height:** The mean values for the symphysis inclination were greatest for the horizontal group with a mean value of 50 ± 7.13 degrees followed by average group with a mean value of 46.88 mm ± 4.93 degrees and then the vertical group with a mean value of 43.12 mm ± 5.71 degrees. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.01 (< 0.05).
8. **Ramus width:** The mean values for the symphysis inclination were greatest for the horizontal group with a mean value of 29.4 mm ± 0.76 degrees followed by average group with a mean value of 28.05 mm ± 4.02 degrees and then the vertical group with a mean value of 26.18 mm ± 3.25 degrees. The post hoc multiple comparisons Bonferroni test results revealed that the vertical group showed significant difference only with the horizontal group with a *p* value of P<0.05 (< 0.05).
9. **Mandibular length:** The mean values for the symphysis inclination were greatest for the horizontal group with a mean value of 113.1 mm ± 9.52 degrees followed by average group with a mean value of 112.77 mm ± 8.63 degrees and then the vertical group with a mean value of 109.75 mm ± 9.73 degrees. The post hoc multiple comparisons Bonferroni test results revealed statistically insignificant results between all the three groups with a *p* value > 0.05.
10. **Body length:** The mean values for the symphysis inclination were greatest for the horizontal group with a mean value of 70.6 mm ± 6.44 degrees followed by average group with a mean value of 68.11 mm ± 8.10 degrees and then the vertical group with a mean value of 65.87 mm ± 5.77 degrees. The post hoc multiple comparisons Bonferroni test results revealed statistically insignificant results between all the three groups with a *p* value > 0.05.

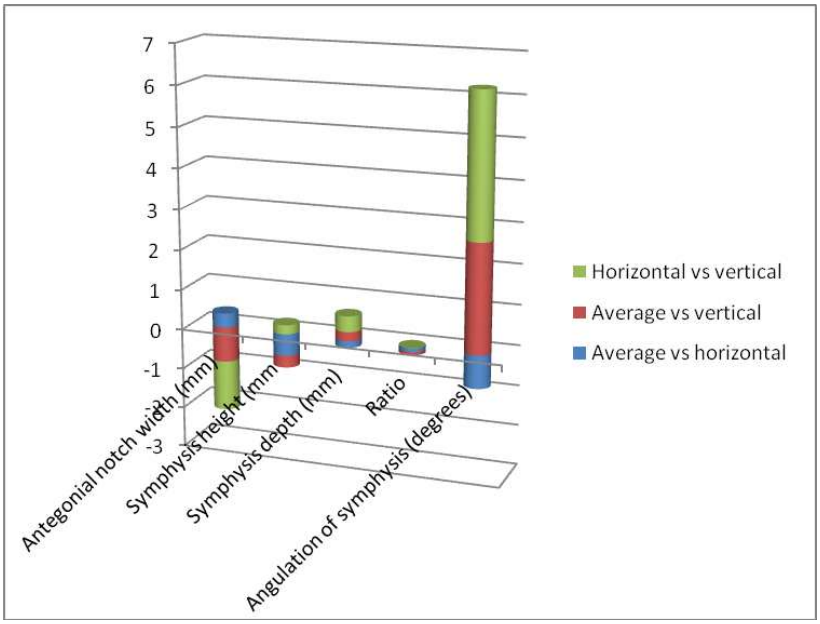

Table 4: Antegonial notch, symphysis height, symphysis depth, ratio and angulation of symphysis

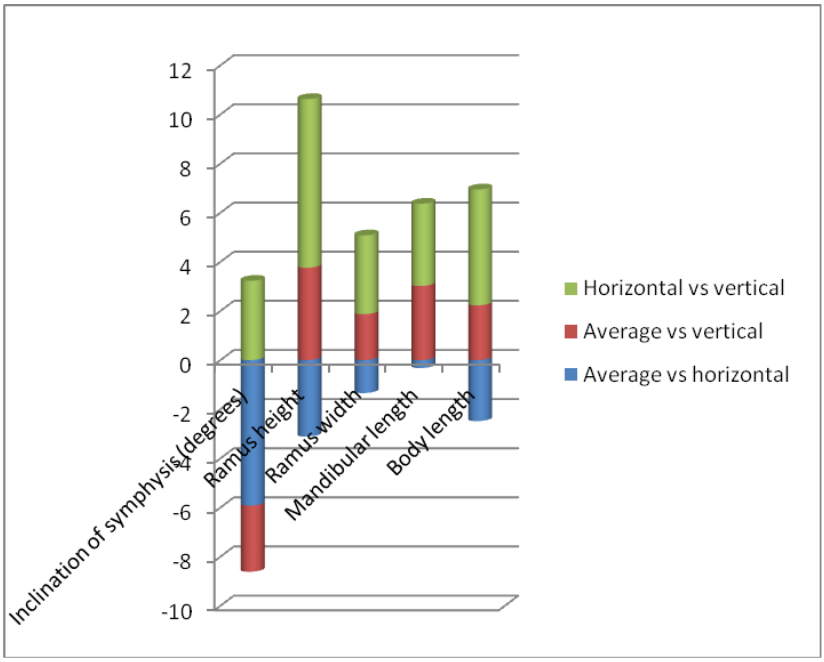

Table 5: Inclination of symphysis, ramus height, ramus width, mandibular length and body length

DISCUSSION

The present retrospective, cross-sectional study was carried out on lateral cephalograms of 80 adults on various parameters like antegonial notch depth, symphysis morphology, ramus and mandibular morphology in different growth patterns in Angle's class I malocclusion. The rationale behind using lateral cephalograms in the present study was it being an essential diagnostic aid and routinely advised in all patients planned for orthodontic treatment. Second, the radiation exposure and cost are less as compared to other diagnostic methods, i.e., cone beam computed tomography, etc. The age group of the patients selected for this study was between 18 and 30 years as most of the growth would have been completed by that time and the growth pattern once established does not change much with age[17].

The ultimate shape of a fully grown mandible is the result of the complex interaction of the growth determinants and functional environment that controls the lower jaw. The antegonial notch lies at the body junction and the ramus of the mandible, and in this strategic position, its shape is probably a good indicator of how the mandible will grow[18]. Hovell[19] in 1964 stated that "when the condylar growth fails to contribute to the lowering of the mandible the bone in the region of the angle grows downward producing antegonial notching caused by the masseter and the medial pterygoid." In our study, the depth of the antegonial notch was found to be highest in vertical growth pattern group and lowest in the horizontal group. Similar findings have been reported by Singer et al[11], Björk and Skieller[20] and Björk[14] in their implant studies. Lambrechts et al[12] noted significant difference in the various cephalometric measurements when he investigated the nature of mandibular growth into two groups with deep and shallow notch depth. He concluded that more vertical mandibular growth patterns was noted in deep antegonial notch group that result in a longer anterior facial height than the shallow notch group. A statistically significant negative relationship was found between mandibular antegonial notch depth and horizontal growth pattern individuals in the study conducted by Kolodziej et al[16]

The anatomy of the mandibular symphysis is an important consideration in evaluating patients seeking orthodontic treatment[10.13] In our study, the symphysis morphology in horizontal growth pattern group was found to be associated with large depth, short height, small ratio (height/depth), and larger angle. In contrast, a symphysis with a smaller depth, larger height, larger ratio, and a smaller angle found in vertical growers. These results are consistent with the findings of Aki et al[10] and Mangla et al[21]. Roy et al[22]also found in his study that the amount of external symphysis increases in size as the facial form differ from vertical to horizontal growth pattern. Ricketts[23] reported an anterior growth direction of the mandible has been associated with thick symphysis. Sassouni and Nanda[24] and Björk[13] have found pronounced apposition with excessive concavity beneath the symphysis of the lower mandibular border associated with the tendency toward backward mandibular jaw rotation. A greater protrusion of the incisors which is esthetically acceptable is attributed to pronounced symphysis, and therefore, a greater chance of nonextraction approach to treatment can be considered. On the contrary, in patients with larger symphyseal height and small chin, an extraction approach is adopted for compensation of arch length discrepencies[25]. These findings are significant with our results as a non-extraction approach is preferred with deep symphyseal depth usually found in horizontal growth pattern group among males whereas in vertical growers, it is better to prefer extraction approach as the symphyseal depth is less in these patients[10]. Inclination of the symphysis to the mandibular plane was statistically significant in average growth pattern than in horizontal growth pattern; however, Arruda et al[26] stated that facial type has no correlation with the symphysis inclination.

Ramus height and width was found to be greater in horizontal growth pattern as compared with average and vertical growth patterns. These findings were consistent with observations by Muller, Schudy, and Sassouni[27-29], who all reported a considerable deficiency in dimension in vertical growers. The mean values mandibular length and body length were greatest for horizontal group as compared

to average and vertical group; however the results were not statistically significant.

CONCLUSION

1. The inclination of the symphysis to the mandibular plane is greater in average growth pattern in Angle's class I malocclusion.
2. The antegonial notch depth is shallow, the symphysis morphology is found to be associated with large depth, short height, small ratio (height/depth), and larger angle, ramus height and width is greater in horizontal growth pattern in Angle's class I malocclusion.
3. Antegonial notch depth is deep, the symphysis morphology is found to be associated with a smaller depth, larger height, larger ratio, and a smaller angle in vertical growth pattern in Angle's class I malocclusion.
4. Antegonial notch depth is greater in the vertical growers as compared to horizontal and average growers. Inclination of the symphysis to the mandibular plane is greater in average growth pattern as compared to horizontal growth pattern. Ramus height and width is greater in the horizontal grower as compared to the vertical grower.
5. From a clinical perspective, the growth pattern of an individual plays an important role in decision making, diagnosis and treatment planning thus indicating the importance of this study.

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