IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 10 Ser.12 (October. 2019), PP 59-66
www.iosrjournals.org

Evaluation of Facial Height Ratios and Growth Patterns in Different Malocclusions in a Population of Dravidian Origin – A Cephalometric study

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Abstract:
Objective: *Every malocclusion can be combined with different facial growth patterns, which are identified as hyper, neutral and hypo divergent growth patterns. Anterior and posterior facial heights usually influence the facial growth pattern of an individual. We evaluated the facial height ratios and pattern of growth in different malocclusions in Dravidian origin subjects.*
Material and Methods: *The pre-treatment digital cephalograms of 150 subjects were selected and divided into 4 groups based on Angle's classification of dentoalveolar malocclusion. All the cephalograms were digitally traced and analyzed with a composite cephalometric analysis including two linear measurements and one angular measurement which was compiled using the FACAD imaging cephalometric software.*
Results: *The linear measurments (AFH, PFH) were lesser than the Caucasian population. Mandibular plane angle was same in both ethnic groups. Overall, Hypo divergent growth pattern was prevalent in Dravidian origin subjects. In group I, II and III (100%) subjects, hypo divergent growth pattern was predominant. In group IV, hypo (43.3%) and normo divergent (36.7%) growth patterns were almost equal. Hyper divergent growth pattern was seen in group I (5%) and group IV (20%) subjects. Females had more hypo divergent growth pattern compared to male subjects. A strong negative correlation was found between mandibular plane angle and Facial height ratio (r = -0.926; p < 0.001).*
Conclusion: *Craniofacial growth pattern is different in each ethnic group. Dravidian origin subjects have predominantly hypo divergent growth pattern in all types of malocclusion.*

Date of Submission: 15-10-2019 Date of Acceptance: 31-10-2019

I. Introduction

Orthodontic diagnosis is key to unveiling the true characteristics of an existing dentofacial deformity. Sagittal jaw base relationship, evaluated by an overall view of the patients' profile, has been emphasised for a precise diagnosis.The first clinical assessments of jaw based relationship was reported in 1899 by Angle based on the first permanent molar relationship.[1] However, it did not take the facial skeleton into consideration, which was emphasised by future studies.[2,3]

In 19th century, studies based on cephalometry, concluded that many malocclusions resulted from faulty jaw relationships rather than malposed teeth. Zhou et al[4] found that the anteroposterior relationship of the dental arch and the jaw-base failed to match in at least one out of every three individuals. The linear measurement of sagittal jaw-base relationship is a more valid reflection of the dental arch relationship than angular measurements. Hence, both linear and angular measurements had been included into various cephalometric analyses for diagnosis of anteroposterior discrepancies and to establish the treatment plan.

In 21st century, the soft tissue paradigm was introduced. It states that "Both the goals and limitations of modern orthodontics and orthognathic treatment are determined by the soft tissue of the face, not by the teeth and bones".[5] Skeletal, dental and soft tissue measurements were obtained by various cephalometric analyses. Soft tissue profile does not always follow skeletal profile in all aspects, due to a wide variability in soft tissue thickness. Thus, evaluation of aesthetics and facial patterns should be conducted during clinical examination and the findings should be correlated with cephalometric radiographs to arrive at a proper diagnosis.

Schudy classified facial pattern based on facial characteristics as hyper divergent, neutral and hypo-divergent facial pattern.[6]Jarabak found different vertical inter-maxillary relationships in Caucasian population.[7] The knowledge of facial growth patterns provided by certain cephalometric analyses can be very useful in establishing precise diagnosis, treatment plan and prognosis.

Studies have compared growth patterns of different races and compared them with Caucasian populations. The relationship between growth patterns and malocclusions in a population of Dravidian origin is not extensively studied. Hence, we evaluated the facial height ratios and pattern of growth in different malocclusions, the correlation between FHR, mandibular plane angle, total anterior facial height (TAFH) and total posterior facial height (TPFH) in Dravidian origin subjects.

II. Materials And Methods

This retrospective study was conducted on the pre-treatment records obtained from the Department of Orthodontics and Dentofacial Orthopedics in a Tertiary care centre located in Chennai, Tamil nadu, India . About 150 patient records (75 males and 75 females), who had consulted between November 2013 to October 2015 were included.

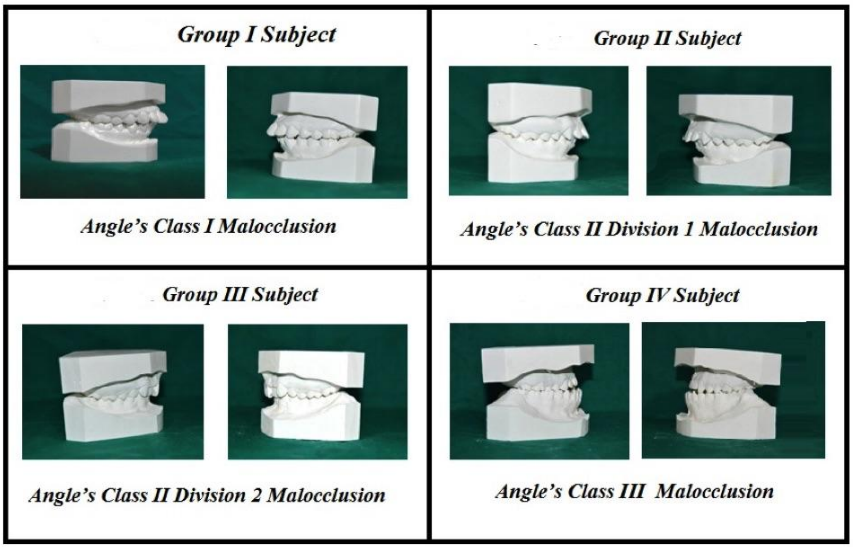
All patients were of Dravidian origin, 18 to 25 years of age, and residents of Chennai (Tamil nadu) atleast 10 years with one of the following mother languages (telugu\tamil\kannada\malayalam), their origin was confirmed from the history recorded during clinical examination questionnaire. The patients also had no previous orthodontic history and systemic medical illness.

All the 150 subjects were divided into four groups based on the Angle's dento alveolar malocclusion, evaluated from the pre-treatment study models in confirmation with photographs and clinical questionnaire record. (Table 1, Fig.1)

Table 1: Division of subjects into four groups based on Angle's classification

Group	Angle's class	No. of patients
I	Class I molar relation (Fig. 1)	60 (30 male and 30 female)
II	Class II division 1 (Fig. 2)	30 (15 male and 15 female)
III	Class II division 2 (Fig. 3)	30 (15 male and 15 female)
IV	Class III molar relation (Fig. 4)	30 (15 male and 15 female)

Fig.1: Impressions of Angle's classes of malocclusion divided into groups I to IV.



Procedure methodology:

All the lateral cephalograms were taken with a PLANMECA (PROMAX) in natural head position.For assessing proper natural head position,the protocol recommended by Beni Solow was followed.[8]Pretreatment digital cephalograms were digitally traced and analyzed with a composite cephalometric analysis including seven linear measurements and one angular measurement compiled using the FACAD AB-2014 imaging cephalometric software (version 3.8.0.0).

Following cephalometric landmarks and planes were used in this study(Fig.2):
Landmarks:
1. **S:**Sellaturcica– mid-point of the hypophysealfossa.
2. **N:**Nasion -most anterior point on the Naso-Frontal suture in the medial plane.
3. **Go:** Gonion - meeting point of posterior ramal plane and the MP angle.
4. **Me:** Menton -most caudal point in the outline ofsymphysismenti.

Constructed planes:
1. **MP:** Mandibular plane - Me to Go.
2. **N-Me line**
3. **S-Go line**

Fig.2: Cephalometric landmarks, constructed planes and angles used in this study.

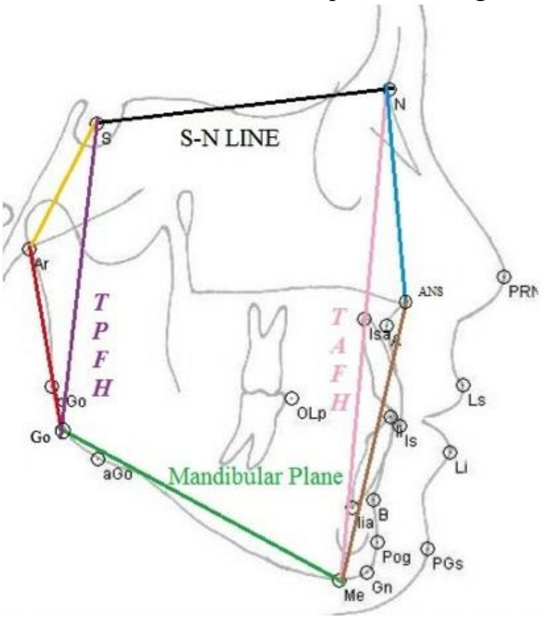
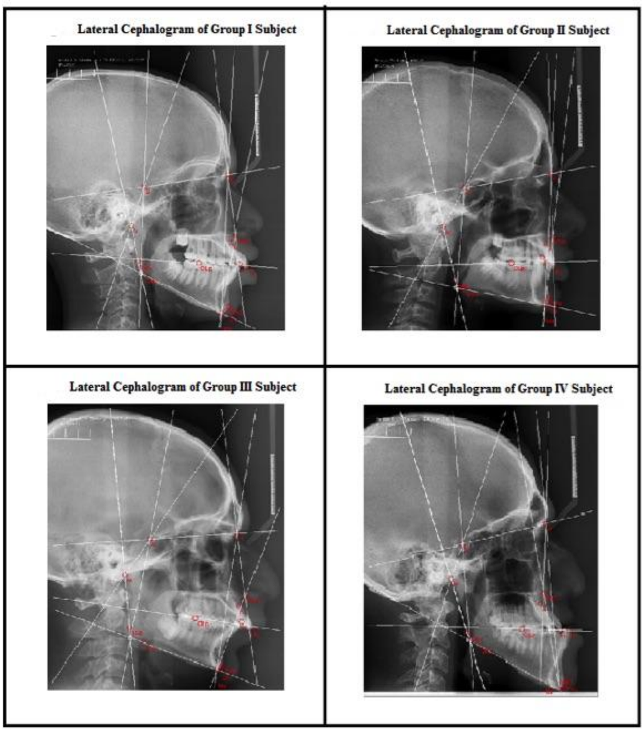


Fig.3: Lateral cephalograms of Group I to IV patients.



Following measurements were obtained using the above planes (Fig.3):

1. **Total anterior facial height (TAFH):** N-Me line.
2. **Total posterior facial height (TPFH):** S-Go line
3. **Facial height ratio (FHR):** It is the ratio of TPFH to TAFH multiplied by 100, also called as Jarabak quotient.

Jarabak categorized facial morphology into three distinct patterns, based on the facial height ratio.[7] These patterns are as follows: -

- **Hyper divergent growth pattern:** FHR <59 %, predominantly vertical growth pattern.
- **Neutral or normo divergent growth pattern:** FHR between 59-63%.
- **Hypo divergent growth pattern:** FHR >63%, predominantly horizontal growth pattern.

Statistical analysis:

All the radiographs were traced and measured by the same investigator to avoid inter-observer error and each measurement was repeated after 2 weeks to reduce intra-observer error. The above parameters were measured and tabulated. Statistical analyses were performed with SPSS ver.20.0 software. (Statistical Package for Social Service; version 20.0). Pearson correlation test was used to determine the correlation between the selected variables. A p-value of <0.05 was taken as the level of significance.

III. Results

The results of this study were statistically analyzed and tabulated.

The mean values of mandibular plane angle, total anterior facial height and total posterior facial height among the four groups is given in table 2. Group IVrecorded the highest mandibular plane angle followed by group I, II and III. Group IV had the highest TAFH and TPFH values. While group III had the lowest TAFH and group I had the lowest TPFH.

Table 2: Mean values of mandibular plane angle, total anterior facial height and total posterior facial height among the four groups

Group	Mandibular plane angle Mean ± SD	TAFH Mean ± SD (mm)	TPFH Mean ± SD (mm)
Group I (n=60)	32.3° ± 5.7°	106.13 ± 8.04	70.27 ± 6.2
Group II (n=30)	28.4° ± 4.1°	106.5 ± 8.03	72.3 ±6.68
Group III (n=30)	27.5°± 5.4°	100.8 ± 5.7	71.7 ± 5.11
Group IV (n=30)	33.64° ± 7.1°	121.58 ± 10.3	78.8 ±10.65

Table 3 showsmean facial height ratios of 150 patients.

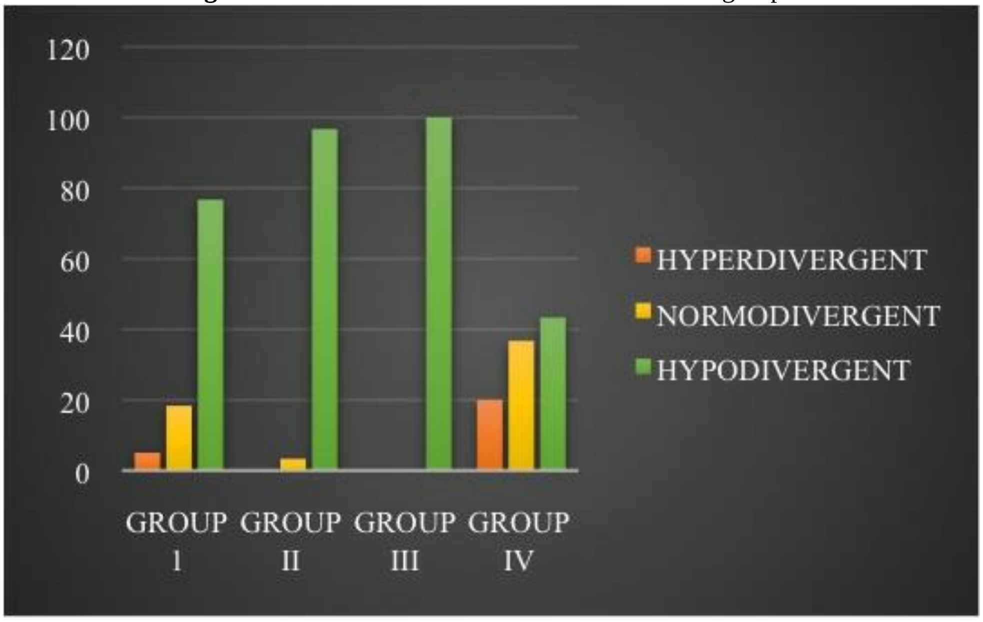
Table 3: Mean Facial Height Ratios of 150 Subjects between Four Groups with Sexual Dimorphism

GROUP	Male Mean ±SD	Female Mean ±SD	Total Mean ±SD	P Value
Group I (n=60)	65.5 ± 4.08	69.99 ± 3.9	66.23 ± 4.05	0.001*
Group II (n=30)	69.69 ± 4..44	69.99 ± 2.2	69.84 ± 3.45	
Group III (n=30)	71.66 ± 3.9	70.6 ± 3.05	71.14 ± 3.5	
Group IV (n=30)	65.04 ± 7.03	65.02 ± 6.01	65.03 ± 6.4	

*p< 0.05 statistically significant

Fig.4 shows the different growth patterns among different groups in both genders. Hypo divergent growth pattern was predominant in all groups followed by normo divergent and hyper divergent growth patterns in total sample (p<0.05).

Fig.4: Distribution of Growth Patterns in different groups.



Different growth patterns of males and females in each group is displayed in Table 4. Among males, In group I (70%) and group II (93.3%) majority of the subjects had hypo divergent growth pattern followed by normo divergent and hyper divergent growth patterns.In group III all subjects (100%) had hypo divergent growth pattern. In group IV most of the subjects had hypo divergent growth pattern (53.3%) followed by hyper divergent (33.3%) and normo divergent (13.3%) growth patterns.Majority of the female patients had hypo divergent growth pattern in first three groups. In group IV majority of patients had normo divergent growth pattern (60%) followed by hypo divergent (33.3%) and hyper divergent (6.7%) growth patterns (p<0.01).

Table 4: Distribution of Growth Patterns among male (n=75) and female (n=75) subjects

Group	Hyper Divergent		Normo divergent		Hypo Divergent		p value	
	Male	Female	Male	Female	Male	Female	Male	Female
Group I	2(6.7 %)	1 (3.3%)	7(23.33 %)	4(13.33%)	21(70.0 %)	25 (83.3%)	< 0.003*	<0.001 *
Group II	0	0	1(6.7 %)	0	14(93.3 %)	15(100%)		
Group III	0	0	0	0	15(100%)	15(100%)		
Group IV	5(33.3 %)	1 (6.7%)	2(13.3 %)	10(60%)	8(53.3%)	4 (33.3%)		

*p< 0. 05 statistically significant

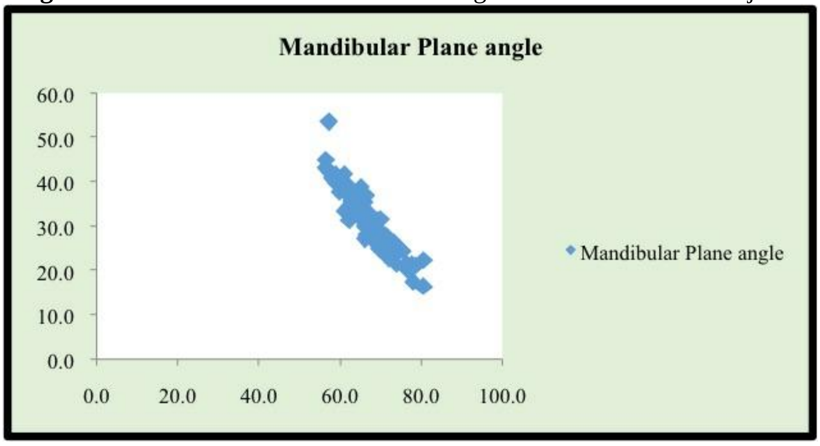
Correlation coefficient of FHR with mandibular plane angle, TAFH and TPFH in different groups were evaluated (Table 5). A strong negative correlation was found between FHR and Mandibular plane angle in all groups in both genders as shown in figure.5.In males FHR and TAFH exhibited a moderate significant negative correlation in group III subjects(r= -0.66**). A strong positive correlation found between FHR and TPFH in group III (r= 0.96**) and group IV (r=0.77**). In females a negative weak correlation found between FHR and TAFH in group I (r= -0.43**) subjects. A moderate positive correlation between FHR and TPFH was seen in group I (r=0.42*) and group III (r=0.67*).

Table 5: Correlation Coefficients of FHR with Mandibular Plane Angle, TAFH and TPFH

	Facial Height Ratio											
	Male				Female				Total			
	Group I	Group II	Group III	Group IV	Group I	Group II	Group III	Group IV	Group I	Group II	Group III	Group IV
MP ANGLE	-0.88**	-0.91**	-0.92**	-0.93**	-0.93**	-0.94**	-0.84**	-0.94**	-0.91**	-0.90**	-0.88**	-0.93**
TAFH	- 0.15	-0.39	-0.66**	-0.23	-0.43*	-0.19	-0.06	-0.40	-0.18	-0.31	-0.31	-0.241
TPFH	0.73	0.41	0.96**	0.77**	0.42*	0.27	0.67*	0.14	0.53*	0.35*	0.84*	0.479*

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level

Fig.5: Correlation of Mandibular Plane Angle and FHR in Total Subjects.



IV. Discussion

Facial harmony is more frequently determined by vertical growth of the mandible. Marked changes in facial pattern is due to the mandibular rotation[6,9]. According to Holdaway the mandibular and maxillary jaw base changes can significantly affect the soft tissue drape.[10]

Several studies have been conducted to assess growth patterns in different malocclusions in various populations.[7,11] These results cannot be directly applied to other racial and ethnic groups due to the significant variations in facial morphology. Hence, the present study aimed to evaluate the facial height ratios and pattern of growth in different malocclusions in Dravidian origin population.

The cranio facial characteristic features of subjects with normal and malocclusion groups became more defined with advancing age,and so the differences are more likely to be found in adult sample.[12]The facial characteristics undergo multiple changes during the growth period, hence to avoid bias in interpreting facial patterns, the subjects between the age group of 18 to 25 years were selected in this study.

The relationship between the anteroposterior dental arch and jaw-base relationships were evaluated and found that Angle's classification of malocclusion alone cannot reveal the entire severity of the dentofacial deformity.[4,13,14] Milacic et al[15] had found a high correlation between molar relation and sagittal skeletal relationship. Vertical growth pattern will have strong influence in the direction of jaw growth which significantly affects the facial heights of an individual.[2] Rotation of the mandible characterizes the facial pattern as hypo divergent or hyper divergent.[6] Hence, for the present study we categorized the subjects into four major groups based on Angle's classification and evaluated the vertical growth pattern parameters.

Mandibular Plane Angle:

The mean mandibular plane angle recorded in the Class I subjects (32.3°±5.7°) were similar to that obtained by Bjork and Jarabak in Caucasian population.[2,7] However in the Japanese- Brazilian population the mean mandibular plane angle (33.4°±3.7°) was slightly higher than our mean value. This difference could be due to the ethnic variation. The mean values for Class II division 1 and division 2 (28.4°±4.1° and 27.5°±5.4° respectively) were lesser than in Class I, indicating predominant hypo divergent pattern in Class II. This is probably due to forward and upward rotation of the mandible.[16,17]Among the Class II subjects, division 2 had lower mandibular plane angle when compared to division 1, which concluded that Class II division 2 subjects are usually associated with upward and forward rotation of the mandible and skeletal deep bite.[18,19,20] In Class III malocclusion, high mandibular plane angle was recorded (33.64°±7.1°), which might be due to the backward and downward rotation of mandible. These findings were in concordance with the study by Sara et al and other earlier studies.[21,22,23,24] Even though mandibular plane angle is an indicator of the divergence pattern of the growth of the mandible, it may or may not have an influence in the facial height. To test this hypothesis, in the present study we assessed the facial height ratios in all the type of malocclusions and correlated with the mandibular plane angle.

Total Anterior Facial Height (TAFH):

The mean TAFH recorded in the Class I subjects (106.13±8.04 mm) showed ethnic variations similar to mandibular plane angle[7,11]. Among Class II subjects (division 1 - 106.5±8.03 mm; division 2 - 100.8±5.7 mm), the mean value of division 1 was similar to that of Class I group. This indicates that Class II division 1 group had low mandibular plane angle with average TAFH and that growth rotation of the mandible was intra matrix rotation. In contrast, division 2 had a low TAFH, indicating that they were usually associated with a reduced anterior facial height and a horizontal growth vector similar to previous studies.[17,18,19,20,25] Class III malocclusion subjects had increased total anterior facial height (mean TAFH 121.58±10.3 mm) emphasising the divergent type of Class III pattern. These findings were in concordance with the study by Guyer et aland others.[22,23,24]

Total Posterior Facial Height (TPFH):

The mean TPFH in Class I subjects (70.27±6.2 mm), were similar to the results that were obtained in Caucasian population[2,7]. However in a cephalometric study, the mean values were lesser than our study, which might be probably due to the manual tracing of conventional cephalograms[26]. In Class II, the mean values (division 1 - 72.3±6.68 mm and division 2 - 71.7±5.11 mm) were similar to the values reported in Caucasian population.[7] Class II division 1 subjects had slightly larger posterior facial height than the Class II division 2 subjects, indicating that the facial height ratio was more in Class II division 1 than that of division 2 group. This finding was supported by Brezniak in his study.[25]In Class III malocclusion group the average TPFH value recorded was high (78.8±10.65mm), which could be due to the large ramus height. Large variations were seen in these values, because of different growth patterns in Class III malocclusion including hypo divergent, normo divergent and hyper divergent.Other studiesalso showed analogous findings in Class III subjects.[24]

Facial Height Ratio (FHR):

Mean value of facial height ratio (FHR) of the Class I subjects (66.23±4.05) was more than the value represented by Jarabak in Caucasian population[7] and indicated that Class I subjects were more towards the hypo divergent facial growth pattern. Females had a tendency towards the hypo divergent growth pattern when compared to males. Majority of subjects in group I had hypo divergent growth pattern followed by normo divergent growth pattern and hyper divergent growth pattern as opposed to predominantly normo divergent growth pattern among Caucasians. This result again emphasises the ethnic variation in growth patterns.

All the above findings suggested that Angle's Class I malocclusion subjects had all three types of growth patterns, but hypo divergent growth pattern was dominant. These growth pattern findings were similar to the previous studies done for Indian population.[26,27] In Class II group, mean values (division 1 - 69.8±3.4 and division 2 - 71.14±3.5) were higher than the Caucasians leading to the conclusion that the subjects in our study exhibited more horizontal growth patterns.[7]There was no sexual dimorphism between males and females. Majority subjects had hypo divergent growth pattern in both groups. These results were supported by studies conducted by Barrett et al. Similar to class II, Class III subjects also had higher mean FHR values (65.03±6.4). Hypo divergent and normo divergent growth patterns were major growth patterns in Class III malocclusion. Similar findings were reported among Caucasians.

Females had more of normo divergent growth pattern whereas males had hypo divergent growth pattern. Very few of hyper divergent growth patterns were seen in females when compared with male population in Class III malocclusion group. These growth pattern findings were similar to the Caucasian population study.[7]

In all types of malocclusion groups, a strong negative correlation found between mandibular plane angle and facial height ratio (r = -0.911), which indicated that the rotation of the mandible is one of the key factor for establishing the growth pattern.[2,3,6] These findings were supported by Jarabak in his study on different growth patterns.[7] Schudy found similar findings only in hypo divergent and hyper divergent facial types.[6] This negative correlation in class II, division I and II group can be attributed to the intra matrix rotation of the mandible.[2,3,18] In Class III malocclusion group, the downward and forward or upward and backward rotation of the mandible determines the growth pattern.[3,22]Also, high FHR values were associated with high TPFH, low TAFH and mandibular plane angle.

Vertical facial changes can influence mandibular position and rotation, either clockwise or counterclockwise, thereby potentially increasing the severity of anteroposterior malocclusion. Malocclusion should be analyzed completely and in all dimensions of space, taking into consideration the facial characteristics specific for particular ethnic and racial groups to achieve appropriate treatment outcome.

Our study had a few limitations. For determining growth pattern only Facial height ratio was taken in this study, but it is not enough to finalize treatment planning. Other analysis like Ricketts, Schwarz analysis also should be considered during diagnosis of an orthodontic case.Since the sample was small, it cannot be extrapolated for the entire Dravidian population.The craniofacial features may vary in different divisions of the Dravidian population.

V. Conclusion

- Hypo divergent growth pattern was dominant in Class I, Class II division 1 and Class II division 2 malocclusion groups.
- Hypo divergent and neutro divergent growth patterns were almost equal in the Class III malocclusion group.
- Majority of subjects demonstrate a hypo divergent growth pattern.

- Strong negative correlation found between mandibular plane angle and FHR.
- Hence, treatment planning should begin with visualization of the final result with respect to both hard tissue and soft tissue changes.

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