ORIGINAL RESEARCH

Jaw Morphology and Vertical Facial Types: A Cephalometric Appraisal

Abhishek Singha Roy, Pradeep Tandon, Anil Kumar Chandna, Vijay P Sharma, Amit Nagar, Gyan P Singh

ABSTRACT

Aims and objectives: To evaluate the maxillary and mandibular morphology in different vertical facial types and to implicate the achieved results into diagnosis and treatment planning of patients requiring orthodontic treatment.

Materials and methods: The present study is conducted on a sample of 120 subjects comprising of 60 males and 60 females in the age range of 18 to 25 years. The lateral head cephalograms of the subjects were divided into three groups, i.e. group I (hypodivergent), group II (normodivergent) and group III (hyperdivergent) with regard to vertical facial type by using the following three parameters, i.e. SN-MP (facial divergence angle), overbite depth indicator (ODI) and Jarabak ratio or facial height ratio (FHR). Differences among the groups and between genders were assessed by means of variance analysis and Newman-Keuls post hoc test.

Results: Maxillary and mandibular anterior alveolar and maxillary postalveolar height was found to be greater for hyperdivergent group in comparison to others. Hyperdivergent facial types posses long and narrow symphysis along with greater antegonial notch depth whereas hypodivergent showed an opposite tendency. Hyperdivergent facial types generally have a smaller maxillary area as compared to other facial types. However, total mandibular area does not vary among different vertical facial types. Sexual dichotomy was found with maxillary anterior alveolar and basal height, mandibular posterior alveolar and basal height, mandibular length, symphyseal depth, depth of the antegonial notch, symphyseal area and ext/total symphyseal area ratio.

Conclusion: Vertical facial type may be related to the morphological and dentoalveolar pattern of both maxilla and mandible. Determination of this relationship may be of great help from diagnostic as well as therapeutic aspects of many vertical malocclusion problems.

Keywords: Vertical facial type, Maxillary and mandibular morphology, Cephalometric.

How to cite this article: Roy AS, Tandon P, Chandna AK, Sharma VP, Nagar A, Singh GP. Jaw Morphology and Vertical Facial Types: A Cephalometric Appraisal. J Orofac Res 2012;2(3):131-138.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

The direction and amount of mandibular growth are important factors in orthodontic diagnosis and treatment planning as normal maxillary and mandibular growth being essential for well-balanced craniofacial development.[1] Vertical development of the facial skeleton has been related to many skeletal units, like the nasomaxillary complex, the alveolar processes and the mandible. These are all associated with normal and abnormal vertical growth pattern as stated by Opdebeeck and Bell.[2] Bjork[3] in his study of craniofacial growth by implant method found that mandibular morphological variations occur when the mandible rotates clockwise or counter-clockwise and that the direction of the mandibular rotation could be predicted by examination of the structural changes.

Betzenberger et al[4] investigated skeletal and dental changes in subjects with different vertical facial types and found that there were definite differences in vertical facial heights and maxilla-mandibular dentoalveolar heights.

These findings suggested that the vertical facial type may be related to the morphological and dentoalveolar pattern of both maxilla and mandible. Determination of this relationship may be of great help from diagnostic as well as therapeutic aspects of many vertical malocclusion problems.

Therefore, the purpose of the present study was to evaluate the maxillary and mandibular morphology in different vertical facial types and to implicate the achieved results into diagnosis and treatment planning of patients requiring orthodontic treatment.

MATERIALS AND METHODS

The present study was conducted on a sample of 120 subjects comprising of 60 males and 60 females in the age range of 18 to 25 years. The lateral head cephalogram for the purpose of study were selected from a random sample of 207 subjects (115 males and 92 females) obtained from the patient record files and from the patients attending the OPD of the Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dental Sciences, CSM Medical University, Lucknow (Uttar Pradesh), India. An informed consent from the patients was taken and ethical clearance was obtained from CSM Medical University ethical committee. The study was designed to be cross-sectional in nature.

All the subjects included in the study were in the age range of 18 to 25 years having full complement of teeth in the permanent dentition except third molars with a negative history of previous orthodontic treatment or trauma to dentofacial region. Individuals with marked jaw asymmetry, temporo-mandibular junction (TMJ) abnormality or craniofacial disorders were excluded from the study.

The lateral head cephalograms were divided into three groups, i.e. group I (hypodivergent), group II (normodivergent), and group III (hyperdivergent) with regard to vertical facial type, by using the following three parameters (Fig. 1):

1. *SN-MP (facial divergence angle)*[5]: The angle gives the inclination of mandible to the anterior cranial base. The subjects were classified into three different groups according to SN-MP angle: As low angle, i.e. <27°, average angle, i.e. 27-37°, and as high angle, i.e. >37°. These values represent one standard deviation (SD) (5.19°) from the average SN-MP angle (31.71°) reported by Riedel.[6]
2. *Overbite depth indicator (ODI)*:[7] It is the combination of two angles, i.e. the angle of the A-B plane to the mandibular plane and the angle of the palatal plane to the Frankfort horizontal plane. The mean value for the angle of the A-B plane to the mandibular plane was 74.0°, with a standard deviation of 4.74. Similarly, the ODI showed a mean value of 74.5°, with a standard deviation of 6.07 and 7.31, for normal occlusion and malocclusion group respectively.
3. *Jarabak ratio or facial height ratio (FHR)*:[8] The ratio of posterior facial height (S-Go) to anterior facial height (N-Me). Jarabak has categorized facial morphology on the basis of three distinct patterns defined by the FHR, or Jarabak quotient.

Only 120 samples (60 males and 60 females) who satisfied at least two out of the above three parameters in any particular group were included in the study. One standard deviation either side of the norm was used to define the group limits. In addition each group was divided into subgroups according to sex (as shown in Table 1).

The cephalometric tracing for area measurement were scanned using scanner (HP 2400). Scanned version of the tracing were then digitized and area measurement were made twice by same operator using AutoCAD® 2006 (Autodesk, SanRafael, California USA). Mean values were used in the study (Fig. 2). Fifteen variables comprising of 11 cephalometric linear parameters, three area parameters and 1 ratio were used to assess the maxillary and mandibular morphology.

Linear Measurement

1. *Maxillary anterior alveolar and basal height (MxAABH)*: The distance between the midpoint of the alveolar meatus of the maxillary central incisor and the intersection between palatal plane and maxillary alveolar axis (Fig. 3).[9]

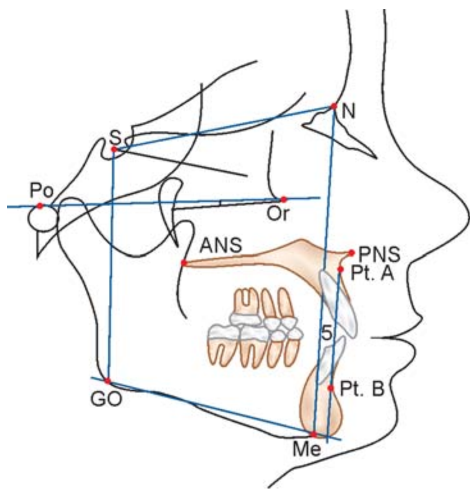

Fig. 1: Parameters used to classify facial types in the study

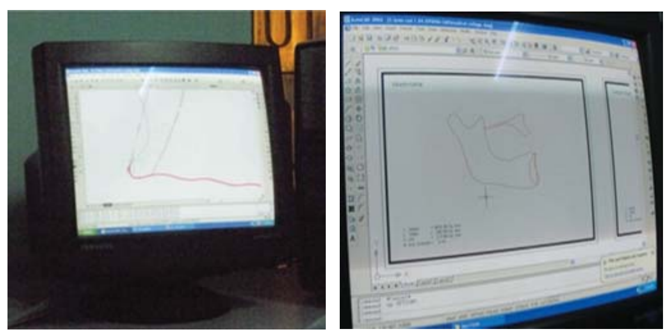

Fig. 2: Digitization and area measurement through AutoCAD

Table 1: Distribution of the study sample according to vertical facial types and sex

Groups	*Subgroups A (male) (n = 60)*	*Subgroups B (female) (n = 60)*
Group I: Hypodivergent (n = 40) SN-MP <27° ODI >81° Jarabak ratio 64-80%	IA (n = 20)	IB (n = 20)
Group II: Normodivergent (n = 40) SN-MP 27°-37° ODI 67°-81° Jarabak ratio 59-63%	IIA (n = 20)	IIB (n = 20)
Group III: Hyperdivergent (n = 40) SN-MP >37° ODI <67° Jarabak ratio 54-58%	IIIA (n = 20)	IIIB (n = 20)

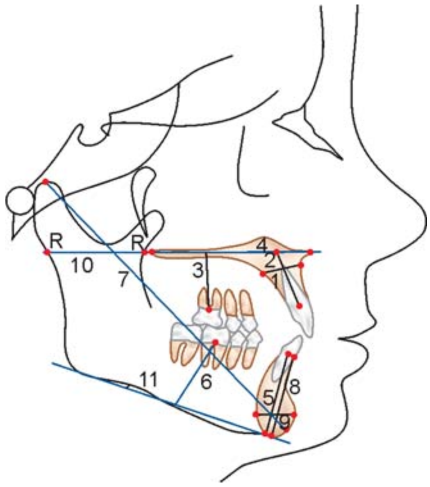

Fig. 3: Cephalometric linear measurements used in the study

2. *Maxillary anterior depth (MxAD)*: The distance between the frontal and dorsal point of shortest line above apex of maxillary central incisors between maxillary midsagittal labial and palatal alveolar cortical bone.[9]
3. *Maxillary posterior alveolar and basal height (MxPABH)*: The perpendicular distance between the midpoint of the alveolar meatus of the maxillary first molar and the palatal plane.[10]
4. *Anterior nasal spine-posterior nasal spine (ANS-PNS)*: The distance between the maxillary ANS and PNS points.[11]
5. *Mandibular anterior alveolar and basal height (Md-AABH)*: The distance between the midpoint of the alveolar meatus of the mandibular central incisor and the intersection between the symphyseal surface and mandibular alveolar axis.[9]
6. *Mandibular posterior alveolar and basal height (Md-PABH)*: The perpendicular distance between the midpoint of the alveolar meatus of the mandibular first molar and the mandibular plane.[10]
7. *Condylion-gnathion (Cd-Gn)*: The distance between condylion and gnathion points.[11]
8. *Symphysis height (SH)*: The distance between infradentale and menton points.[10]
9. *Symphysis depth (SD)*: The distance between pogonion and the most posterior wall of the symphysis.[10]
10. *Ramus width (RW)*: The distance between R and R′ points. (R and R′ points are anterior and posterior intersecting points of a posterior extension of the palatal plane on the mandibular ramus).[10]
11. *Depth of antegonial notch (ND)*: Measured as the distance along a perpendicular line from the deepest point of notch concavity to a tangent through the two points of greatest convexity on the inferior border of the mandible, either side of the notch.[12]

Area Measurement

12. *Maxillary area (MxA)*: The total area of the maxilla (Fig. 4).[10]
13. *Total mandibular area (TmdA)*: The total area of mandible.[13]
14. *Symphysis area (SA)*: The total area of the symphysis.[14]

Ratio

One ratio was used to asses symphyseal morphology.

15. *External/Total symphyseal area ratio*: The area of the external chin, as restricted posteriorly by the infradentale-menton line was assessed. This measurement of protruding portion of the chin is divided by the total symphyseal area and expressed as ratio.[14]

 The data obtained after measuring the parameters were then subjected to the statistical analysis. Descriptive statistics, including the mean and standard deviation values were calculated for all the parameters in each group. Two-factor analysis of variance (ANOVA) was used to determine if significant difference were present in the groups with different vertical facial type and between the sex. Newman-Keuls post hoc test was then used to determine the significant differences between the mean and standard deviations of various parameters in each group among different sex. The same test was also used to compare the variables between the groups for each sex.

RESULTS

The results indicated that between sex MdPABH and Cd-Gn demonstrates moderately significant (<0.01**) sex difference. While the parameters like MxAABH, SD, ND, SA and external/total symphyseal area ratio (<0.05) were just significant between the sex. ANOVA among the groups showed highly significant ($p < 0.001$) difference for the MxPABH, SH, SD, ND and external/total symphyseal area ratio (Table 2).

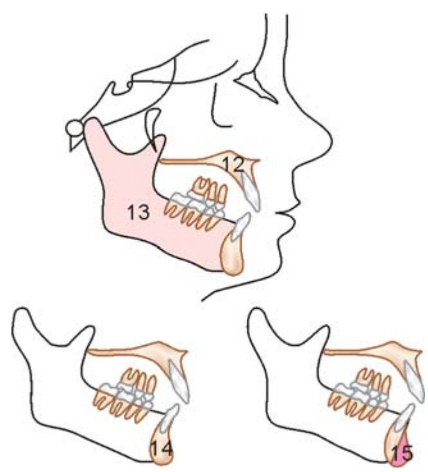

Fig. 4: Cephalometric area measurements used in the study

Table 2: Analysis of variance for various parameters for group and sex

S.no.	Parameters	Between sex		Among groups	
		f-value (df = 1,113)	*p-value*	*f-value (df = 2,133)*	*p-value*
Linear (mm)					
1.	MxAABH	0.63	0.02*	15.92	0.02*
2.	MxAD	1.82	0.18 NS	2.82	0.06 NS
3.	MxPABH	1.20	0.28 NS	18.89	0.001**
4.	ANS-PNS	0.17	0.68 NS	5.63	0.03*
5.	Md-AABH	0.91	0.34 NS	43.72	0.0009***
6.	Md-PABH	169.86	0.005**	0.23	0.79 NS
7.	Cd-Gn	50.26	0.002**	0.48	0.62 NS
8.	SH	3.40	0.07 NS	46.53	0.0005***
9.	SD	11.58	0.03*	21.19	0.0004***
10.	RW	0.30	0.58 NS	1.33	0.27 NS
11.	ND	18.03	0.02*	20.76	0.0008***
Area (mm^2)					
12.	MxA	0.00	0.99 NS	4.30	0.02*
13.	TmdA	0.39	0.54 NS	1.66	0.19 NS
14.	SA	0.01	0.02 *	3.93	0.93 NS
Ratio					
15.	Ext/total SA ratio	23.60	0.03*	475.78	0.0007***

p-value: NS > 0.05 = nonsignificant; *:<0.05 just significant; **:<0.01 moderately significant; ***:<0.001 highly significant

When compared between group I (hypodivergent) and group III (hyperdivergent), both sex exhibited and increased value of MxAABH, MxPABH, MdAABH, SH and depth of antegonial notch (ND) in group III as compared to group I. Whereas SD and ext/total SA ratio were found to be less in group III as compared to group I. But the value of ANS-PNS and MxA were decreased in group III as compared to group I for the female subjects only.

When compared between group II (normodivergent) and group III (hyperdivergent) in both male and female MdAABH and SH were found to be increased in group III as compared to group II whereas the value of SD and ext/total SA ratio were decreased in group III as compared to group II. But the value of ND and MxAABH were specifically raised in group III for male and female subjects respectively (Tables 3 and 4).

Table 3: Test of significance for various parameters among the subgroups in male

S. no.	Parameters	Subgroup IA	Subgroup II A	Subgroup III A	p-value		
		Mean ± SD	*Mean ± SD*	*Mean ± SD*	*IA vs IIA*	*IA vs IIIA*	*iIA vs IIIA*
Linear (mm)							
1.	MxAABH	18.03 ± 0.43	19.60 ± 0.59	21.03 ± 0.48	0.11	0.009**	0.17
2.	MxAD	18.95 ± 0.85	18.45 ± 0.4	17.63 ± 0.40	0.48	0.34	0.65
3.	MxPABH	15.13 ± 0.45	16.60 ± 0.63	17.88 ± 0.35	0.04*	0.007**	0.10
4.	ANS-PNS	55.68 ± 0.85	55.08 ± 0.84	53.68 ± 0.59	0.91	0.04*	0.13
5.	Md-AABH	32.88 ± 0.77	33.60 ± 0.49	37.90 ± 0.72	0.66	0.003**	0.02*
6.	Md-PABH	26.48 ± 0.53	26.20 ± 0.55	25.85 ± 0.51	0.66	0.58	0.58
7.	Cd-Gn	122.73 ± 1.89	123.50 ± 1.12	123.00 ± 1.34	0.91	0.88	0.79
8.	SH	33.65 ± 0.80	34.50 ± 0.53	38.60 ± 0.61	0.53	0.002**	0.04*
9.	SD	16.80 ± 0.36	16.65 ± 0.38	14.25 ± 0.54	0.79	0.009**	0.02*
10.	RW	39.35 ± 0.62	38.58 ± 0.74	38.45 ± 0.62	0.57	0.76	0.99
11.	ND	1.38 ± 0.16	1.68 ± 0.15	2.53 ± 0.18	0.20	0.0009***	0.04*
Area (mm^2)							
12.	MxA	432.15 ± 8.69	429.04 ± 6.69	408.78 ± 3.17	0.99	0.02*	0.11
13.	TmdA	3798.26 ± 88.11	3675.46 ± 64.08	3610.51 ± 91.54	0.54	0.32	0.76
14.	SA	378.70 ± 6.06	362.19 ± 8.18	355.04 ± 5.73	0.52	0.29	0.55
Ratio							
15.	Ext/total SA ratio	0.515 ± 0.15	0.247 ± 0.010	0.154 ± 0.014	0.008**	0.009**	0.002**

p-value: NS > 0.05 = nonsignificant; *:<0.05 just significant; **:<0.01 moderately significant; ***:<0.001 highly significant

Table 4: Test of significance for various parameters among the subgroups in female

S. no.	Parameters	Subgroup IB	Subgroup IIB	Subgroup IIIB	p-value		
		Mean ± SD	Mean ± SD	Mean ± SD	IB vs IIB	IB vs IIIB	iIB vs IIIB
Linear (mm)							
1.	MxAABH	17.68 ± 0.65	18.85 ± 0.47	20.90 ± 0.66	0.21	0.007**	0.04*
2.	MxAD	18.25 ± 0.35	17.84 ± 0.37	17.23 ± 0.32	0.61	0.48	0.62
3.	MxPABH	14.78 ± 0.26	16.35 ± 0.35	17.28 ± 0.43	0.02*	0.009**	0.32
4.	ANS-PNS	55.35 ± 0.54	55.13 ± 0.18	53.30 ± 0.57	0.81	0.16	0.19
5.	Md-AABH	32.15 ± 0.57	33.03 ± 0.59	37.50 ± 0.37	0.33	0.002**	0.03*
6.	Md-PABH	20.85 ± 0.36	21.80 ± 0.29	21.75 ± 0.35	0.16	0.33	0.98
7.	Cd-Gn	114.30 ± 0.97	115.13 ± 0.85	116.35 ± 1.52	0.47	0.52	0.71
8.	SH	32.45 ± 0.51	34.00 ± 0.30	37.78 ± 0.46	0.13	0.008**	0.02*
9.	SD	15.88 ± 0.39	14.95 ± 0.37	13.45 ± 0.35	0.13	0.007**	0.02*
10.	RW	38.98 ± 0.19	38.51 ± 0.40	38.20 ± 0.44	0.79	0.85	0.93
11.	ND	0.85 ± 0.13	1.28 ± 0.18	1.78 ± 0.17	0.10	0.006**	0.10
Area (mm^2)							
12.	MxA	431.20 ± 11.09	427.25 ± 12.98	407.94 ± 7.67	0.99	0.35	0.26
13.	TmdA	3675.78 ± 29.57	3672.41 ± 43.44	3628.16 ± 42.95	0.95	0.86	0.94
14.	SA	375.74 ± 9.79	359.09 ± 11.93	351.78 ± 10.61	0.46	0.28	0.61
Ratio							
15.	Ext/total SA ratio	0.435 ± 0.011	0.205 ± 0.008	0.142 ± 0.004	0.04*	0.008**	0.009**

p-value: NS > 0.05 = nonsignificant; *:<0.05 just significant; **:<0.01 moderately significant; ***:<0.001 highly significant

DISCUSSION

Recently, great emphasis has been placed on the vertical dimensions of facial morphology as they contribute to a large extent to malocclusions resulting from vertical dysplasia. Many studies[15,16,17] have been undertaken in an attempt to establish relationships between overbite and maxillary and mandibular dentoalveolar heights. Ceylan[10] investigated the relationship between the amount of overbite and the maxillary and mandibular morphology and found that definite morphological differences were present between subjects with varying amount of overbite. However, until now, relationships between vertical facial types and overall maxillary and mandibular morphology have not been investigated in detail. In the present study an attempt was made to determine whether different vertical facial types were associated with particular maxillary and mandibular morphological traits.

The age group (18-25 years) considered in the study represented a very stable period in the growth and development of head and face. The influence of growth is less and the permanent dentition present is beyond the variability seen during the period of mixed dentition. This view was supported by Altemus.[18] Moreover, a constant skeletal pattern is established which is subject to less changes.[19]

According to Schudy[20] the face grows from two to three times as much vertically as anteroposteriorly; it seems logical to use such growth as the basis for facial typing. Group allocation was done with regard to vertical facial type by using the following three parameters, i.e. SN-MP (facial divergence angle),[5] overbite depth indicator (ODI)[7] and Jarabak ratio or facial height ratio (FHR).[8] Only subjects who satisfied at least two out of the above three parameters in any particular group were included in the present study. This sample selection was in accordance with the Bishara and Augspurger[21] and Opdebeeck[2] who stated that a single parameter is not sufficient to accurately identify a given facial type.

Previous studies[5,17,22,23] have found sexual dimorphism among various facial types. Hence, there was a need to segregate the sample according to sex to maintain homogeneity of the sample.

Result of the study indicate maxillary and mandibuar anterior alveolar and basal height (MxAABH and MdAABH) were greater in hyperdivergent facial type than other facial types.[9,10] This observation suggests a compensatory mechanism by enlarging the frontal part of the jaw in such a way that normal overbite can occur in hyperdivergent people as explained by Solon.[24] Because mandibular incisal alveolar growth is perhaps the most important and natures best compensating factor in bringing about morphological and functional harmony whenever, there is a tendency for hyperdivergency of the jaws exist.[25] Anwar et al[26] in their study showed that the lower incisors is the most compensated dentoalveolar parameter for different vertical skeletal dysplasias; their pretreatment height and inclination are of importance with regards to the stability of any changes planned. Similarly maxillary posterior alveolar and basal height (MxPABH) was also scored a higher value for both sex in hyperdivergent group than hypodivergent group. It has been reported[10,17,27,28] that excessive posterior dentoalveolar heights were a common feature of long face syndrome. Similar findings were also reported by Issacson et al[29] who found that amount of maxillary posterior alveolar development decreases as the SN-MP angle decreased. So in hyperdivergent subjects, if an increased posterior dental height is found, treatment should be aimed at its reduction by orthodontic mechanics (intrusion). On the other hand, if the posterior height is within normal limits, the likely cause of hyperdivergence is tilting of posterior palatal plane and a combined orthodontic orthognathic treatment approach may be required.[26] Intergroup comparison of mean value of linear parameter is shown in Figure 5.

Intergroup comparison also revealed that hyperdivergent facial types showed long symphysis height and narrow symphysis depth while hypodivergent facial types revealed opposite tendency, which might be a part of compensatory mechanism simultaneously enlarging the vertical dimensions while reducing the labiolingual dimensions of the symphysis in such a way that normal or deep bite can occur in people with hyperdivergent faces.[9,30] The size and shape of the mandibular symphysis is an important consideration in evaluation of orthodontic patients.[31] With a large symphysis, greater protrusion of incisors is esthetically acceptable and therefore there is greater chance of a nonextraction treatment approach. Conversely, persons with greater symphysis height and a small chin would be candidates for an extraction treatment plan to compensate for arch length discrepancies.

Also the amount of external symphysis increases in size as the facial types varies from a hyperdivergent to a hypodivergent types of face as shown in Figure 6. This finding was also supported by Haskell[14] who measured the amount of protruding chin area as a percentage of total mandibular alveolar and basal area in subjects with open and normal or deep bites and found that patients with open bite showed a smaller protruding chin area, related to their total mandibular alveolar and basal area. Hylander[32] proposed that the symphysis is necessary to mitigate shear stress distributed through the

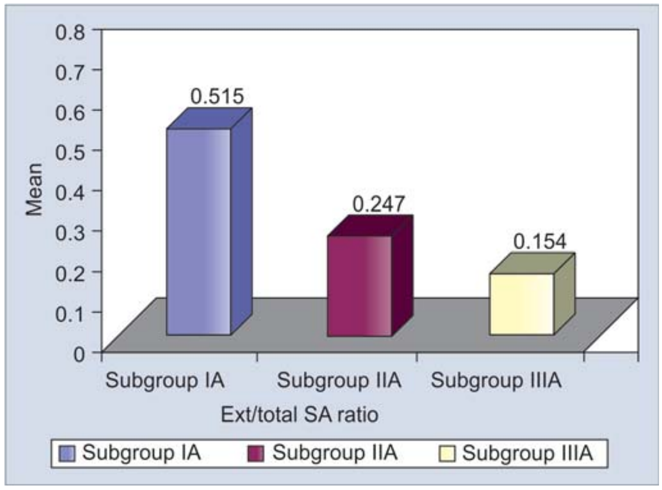

Fig. 6: Intergroup comparison mean value of ratio parameter in males

mandible as a result of a 'balancing' posterior bite. The reduction of protruding chin in the openbite cases may be due the loss of incisal bite stress in mastication.

The depth of the antegonial notch (ND) was found to be increased for both males and females of hyperdivergent group when compared to other groups. This findings was supported by Bjork[3] who in his implant study clarified that the direction of madibular growth rotation was reflected in the location and degree of remodeling on the inferior surface of the mandible and the most pronounced area of remodeling was below the angular region. Also in our present study mandibular length (Cd-Gn) tends to be smaller in the hyperdivergent group; further strengthens the association between reduced amount of mandibular growth (as reflected by decreased mandibular length) and deep antegonial notch.[12] The short mandibular length associated with hyperdivergency does not permit the mandibular ramus surgery to be carried out alone to correct the problem. This rotation lengthens the ramus and stretches the muscles of the pterygoid sling, causing relapse to occur, and hence should be combined with maxillary intrusion to avoid any ramus lengthening.

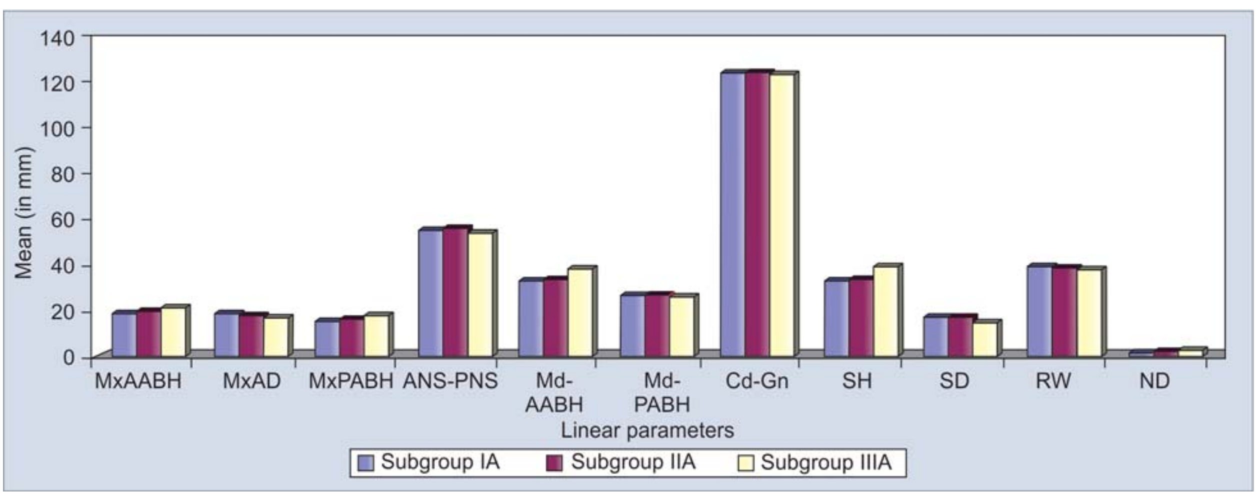

Fig. 5: Intergroup comparison of mean value of linear parameters in males

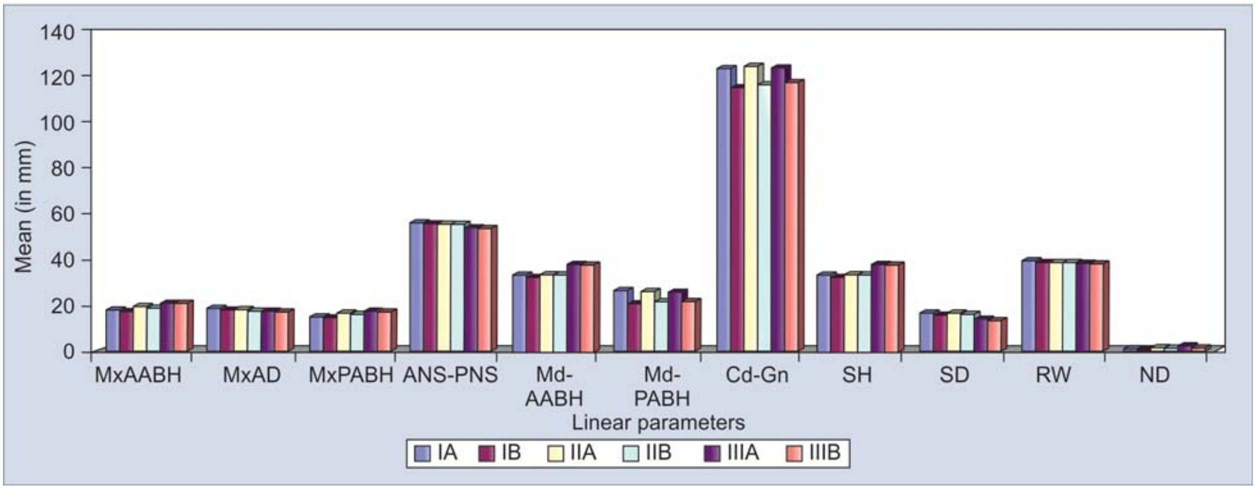

Fig. 7: Mean value of various parameters among the subgroups

Morphologic variations between hyper- and hypo-divergent persons results in a significant difference in the mechanical advantage of the jaw muscles. This had a bearing on the orthodontic tooth movement. Higher extrusive forces are required to overcome the increased mechanical advantage of the musculature in hypodivergent cases. However, such forces are controlled along with a tight monitoring on the sagittal changes to prevent the mesial migratory forces on the dentition in hyperdivergent facial types because of the weaker musculature.

Maxillary anterior alveolar and basal height, Mandibular posterior alveolar and basal height, mandibular length, symphyseal depth, depth of the antegonial notch, symphyseal area and ext/total symphyseal area ratio showed significant differences between sexes; indicates that sexual dimorphism was evident in maxillary and mandibular morphology (Fig. 7).

Hyperdivergent facial types generally have a smaller maxillary area as compared to other facial types. However, total mandibular area does not vary among different vertical facial types. This finding was supported by Ferrario et al[13] who studied the relationship between mandibular size and shape with skeletal divergency and found that hyperdivergent subjects generally have a smaller maxilla and mandible. Nair et al[33] in their study of quantative analysis of maxilla and mandible in hyperdivergent and hypodivergent skeletal pattern showed that maxillary size is less in hyperdivergent sample.

CONCLUSION

Following conclusions were drawn on the basis of the findings of this study:

1. Maxillary anterior and posterior alveolar and basal height (MxAABH and MxPABH) and mandibular anterior alveolar and basal height (MdAABH) were greater in the hyperdivergent facial type than the other facial types.
2. Hyperdivergent facial types showed long symphysis height and narrow symphysis depth while hypodivergent facial types revealed opposite tendency. Also the amount of external symphysis increases in size as the facial types varies from a hyperdivergent to a hypodivergent types of face.
3. Hyperdivergent facial types possess greater antegonial notch depth as compared to hypodivergent facial types.
4. The fact that maxillary anterior alveolar and basal height, mandibular posterior alveolar and basal height, mandibular length, symphyseal depth, depth of the antegonial notch, symphyseal area and ext/total symphyseal area ratio showed significant differences between sexes; indicates that sexual dimorphism was evident in maxillary and mandibular morphology up to a certain extent.
5. Hyperdivergent facial types generally have a smaller maxillary area as compared to other facial types. However, total mandibular area does not vary among different vertical facial types.

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