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Original Research Article

The comparison between the lower airway space, mandibular body, mandibular ramus, chin thickness and chin throat length in vertical and horizontal growers among skeletal class I and skeletal class II patterns – Retrospective cephalometric study

Vighanesh Kadam[1,*], Hrushikesh Aphale[1], Sunil Kumar Nagmode[1], Vasant Pawar[1], Kunal Patil[1], Deepak Sahane[1], Vivek Shinde[1]

[1] *S.M.B.T Dental College and Research Center, Sangamner, Maharashtra, India*

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ABSTRACT

Introduction: The vertical and horizontal growth influences the height of mandibular ramus and length of the mandibular body. The soft tissue chin thickness, the lower airway space and the chin throat length can vary in different growth patterns and different skeletal patterns.
Materials and Methods: Lateral cephalograms of non-growing patients seeking orthodontic treatment (n=120) were included in the study. The samples were divided into two subgroups based on skeletal pattern (Cl I & Cl II) according to ANB angle and Wit's appraisal. Further sub divided into four groups based on cephalometric mandibular plane inclination to anterior cranial base (SN-GoGn) and Frankfort's mandibular plane (FMA) angle in hypodivergent and hyperdivergent patterns. The parameters lower airway space, mandibular body, mandibular ramus, chin thickness and chin throat length were measured.
Result: Results showed maximum lower airway space, mandibular body, mandibular ramus, chin thickness, and chin throat length in the hypodivergent skeletal Class I group. The minimum lower airway space, mandibular body, mandibular ramus, chin thickness, and chin throat length observed in the hyperdivergent skeletal Class II group. The inter-group comparison of all samples indicates that there was a statistically significant difference between various groups and the measures of the hypodivergent samples are more than the hyperdivergent samples irrespective of the skeletal pattern.
Conclusion: The study concludes that the lower airway, mandibular ramus, mandibular body, soft tissue chin thickness, chin throat length was less in hyperdivergent skeletal Class I and skeletal Class II samples than the skeletal Class I and skeletal Class II hypodivergent.

1. Introduction

The face is a complex and dynamic structure comprising of various soft-tissue and hard tissue units. The optimal relationship between the soft tissue units and skeletal units is responsible for an aesthetically appealing face. It is however important to examine the soft tissue units individually to eliminate any unnecessary influence that other units may have on the perception of the face. 1 The vector of growth of the mandible occurs in either clockwise (vertical) or counter clockwise (horizontal) direction. This growth influences the lower airway space, height of mandibular ramus, length of mandibular body, chin thickness and chin throat length. The soft tissue chin thickness, the lower airway space and the chin throat length can vary in different growth patterns. Hence the aim of the study is to compare lower airway

* *Corresponding author*.
E-mail address: vighaneshkadam99@gmail.com (V. Kadam).

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space, mandibular ramus, mandibular body, chin thickness and chin throat length in vertical and horizontal growers among skeletal class I and class II patterns.

2. Materials and Methods

The samples were collected from the database of the Department of Orthodontics and Dentofacial Orthopaedics in our institution.

Lateral cephalograms of non-growing patients seeking orthodontic treatment (n=120), from ages 20 - 30 years were included in the study. The magnification of lateral cephalograms was standardized to the resolution of 80% for all the samples. The cephalometric tracing was done on acetate matte paper with 0.3mm pencil. The points for the parameters were marked as shown in Image 1. The angular measurements were done using mathematical protractor and linear measurements done with graduated measuring scale.

2.1. Blinding

To eliminate error and bias, 60 set of cephalograms were randomly selected and measurements were conducted by two operators at two intervals. The co-relation co-efficient between the intra-operator measurements and inter-operator measurements were examined. The co-relation co-efficient for the inter-operator measurements was r ~ 0.92 and intra-operator measurements was r ~ 0.96. It is inferred that the intra-operator reproducibility was more than the inter-operator measurement. However both the measures were reliable.

These lateral cephalograms were divided into two subgroups based on skeletal pattern according to ANB angle and Wit's appraisal:

Skeletal Class II pattern - ANB angle >3°and Wit's appraisal – Males >2mm and Females >1mm (n=60)

Skeletal Class I pattern – ANB angle 2° - 3° and Wit's appraisal – Males - 1mm - 2mm and Females – 0mm - 2mm (n=60)

Further sub divided into four groups based on cephalometric mandibular plane inclination to anterior cranial base (SN-GoGn) and Frankfort's mandibular plane (FMA) angle. The hyperdivergent samples were according to SN-GoGN >34°; FMA >27° and the hypodivergent were according to SN-GoGN < 30°; FMA < 23°:

Group A - Skeletal Class I Hyperdivergent (n=30)

Group B – Skeletal Class I Hypodivergent (n=30)

Group C - Skeletal Class II Hyperdivergent (n=30)

Group D – Skeletal Class II Hypodivergent (n=30)

The lower airway space was measured from the intersection of the posterior border of the tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall. (Figure 1).

The mandibular ramus from Co-Go (Condylion - Gonion) was measured and the mandibular body from Go-Gn (Gonion - Gnathion) was measured (Figure 2).

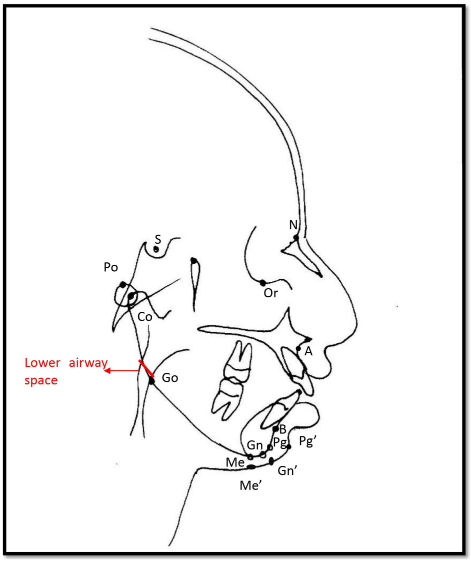

Fig. 1:

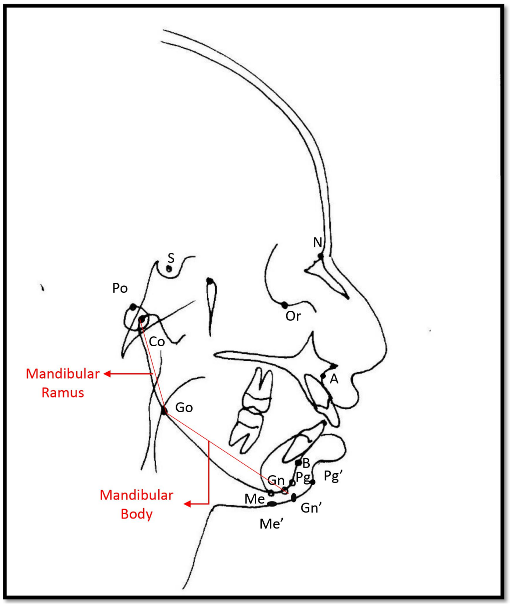

Fig. 2:

Soft tissue chin thickness Pog-Pog' (Pogonion – soft tissue Pogonion), Gn-Gn' (Gnathion – soft tissue Gnathion) and Me-Me' (Menton – soft tissue Menton) was measured (Figure 3).

The chin throat length, the distance from a tangent to the angle of the throat to the soft tissue menton was measured (Figure 4).

The measured values of the parameters of four groups were compared with each other and individual comparison was done.

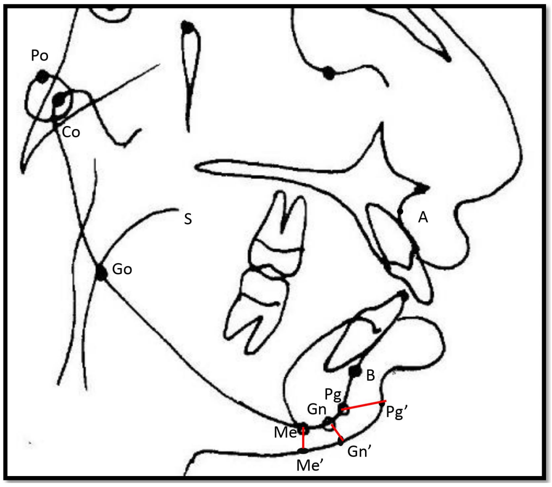

Fig. 3:

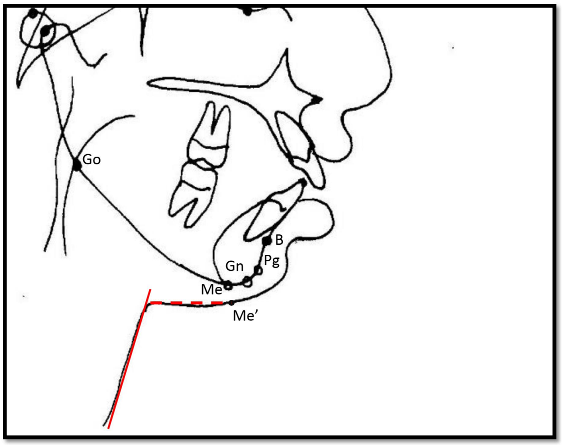

Fig. 4:

2.2. *Statistical analysis*

SPSS for Windows, Version 21.0. Chicago, SPSS Inc software was used to analyse the data. Statistical analysis was done by using tools of descriptive statistics such as Mean, and SD for representing quantitative data. Shapiro Wilk test was used to test normality of data (parametric or non –parametric nature) ANOVA F test was applied for overall intergroup comparison between four different study groups in relation to continuous parametric variables like lower airway, mandibular length, chin thickness and chin throat length respectively. Post hoc data analysis which follows ANOVA F test was done by using Tukey's multiple comparison test was also used. Tukey's post hoc test which analyses multiple pair –wise individual comparison was also used. Probability $p<0.05$, considered as significant as alpha error set at 5% with confidence interval of 95% set in the study. Power of the study was set at 80% with beta error set at 20%.

3. Results

Table 1 A, contains the measures of the lower airway space. The maximum lower airway space was seen in the hypodivergent skeletal Class I group (Group B). The minimum airway space was seen in the hyperdivergent skeletal Class II group (Group C).

Table 1 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples are more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 2 A, contains the measures of the height of the mandibular ramus. The maximum height of the mandibular ramus was seen in the hypodivergent skeletal Class II (Group D). The minimum height of the mandibular ramus was in the hyperdivergent skeletal Class II (Group C).

Table 2 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 3 A, contains the measures of length of the mandibular body. The maximum length of the mandibular body was seen in the hypodivergent skeletal Class I (Group B). The minimum length of the mandibular body was seen in the hyperdivergent skeletal Class II (Group C).

Table 3 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 4 A, contains the measures of the chin thickness between Pog – Pog'. The maximum chin thickness between Pog – Pog' was seen in the hypodivergent skeletal Class II (Group D). The minimum chin thickness between Pog – Pog' was seen in the hyperdivergent skeletal Class II (Group C).

Table 4 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 5 A, contains the measures of the chin thickness between Gn – Gn'. The maximum chin thickness between Gn – Gn' was seen in the hypodivergent skeletal Class I (Group B). The minimum chin thickness between Gn – Gn' was seen in the hyperdivergent skeletal Class II (Group C).

Table 5 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 1: Comparison of lower airway (in mm) between four groups respectively

Lower Airway (in mm)	Mean	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	5.56	0.89	F = 146.55	p < 0.001**
Group B (Hypodivergent Class I)	9.93	1.17		
Group C (Hyperdivergent Class II)	4.43	1.04		
Group D (Hypodivergent Class II)	8.40	1.40		

Table 1 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	4.36	p < 0.001**
Group A vs Group C	1.13	p = 0.001*
Group A vs Group D	2.83	p < 0.001**
Group B vs Group C	5.5	p < 0.001**
Group B vs Group D	1.53	p < 0.001**
Group C vs Group D	3.96	p < 0.001**

p>0.05 – not significant *p<0.05 – significant **p<0.001 – highly significant

Table 2: Comparison of mandibular dimension [Co-Go] (in mm) between four groups respectively

Co-Go	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	37.86	2.94	F = 61.39	p <0.001**
Group B (Hypodivergent Class I)	45.26	3.15		
Group C (Hyperdivergent Class II)	37.26	3.08		
Group D (Hypodivergent Class II)	45.73	3.85		

Table 2 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	7.76	p < 0.001**
Group A vs Group C	0.60	p =0.894
Group A vs Group D	7.86	p < 0.001**
Group B vs Group C	8.36	p < 0.001**
Group B vs Group D	0.10	p = 0.999
Group C vs Group D	8.46	p < 0.001**

p>0.05 – not significant *p<0.05 – significant **p<0.001 – highly significant

Table 6 A, contains the measures of the chin thickness between Me – Me'. The maximum length of the chin thickness between Me – Me' was seen in the hypodivergent skeletal Class I (Group B). The minimum length of the mandibular body was seen in the hyperdivergent skeletal Class II (Group C).

Table 6 B, shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

Table 7 A, contains the measures of the chin throat length. The maximum length of the chin throat length was seen in the hypodivergent skeletal Class II (Group D). The minimum length of the chin throat length was seen in the hyperdivergent skeletal Class II (Group C).

Table 7 B shows the intergroup comparison of all samples. It indicates that there was a statistically significant difference between various groups. It can be inferred that the measures of the hypodivergent samples is more than the hyperdivergent samples irrespective of the skeletal pattern.

4. Discussion

This study introduced the comparison of chin throat length, lower airway space, mandibular body, mandibular ramus and soft tissue chin thickness in the hyperdivergent and the hypodivergent patients with skeletal Class I and skeletal Class II patterns.

Table 3: A: Comparison of mandibular dimension [Go -Pog] (in mm) between four groups respectively

Go - Pog	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	50.13	4.36	F = 26.55	p <0.001**
Group B (Hypodivergent Class I)	55.03	2.05		
Group C (Hyperdivergent Class II)	49.36	3.82		
Group D (Hypodivergent Class II)	54.83	1.72		

Table 3 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	4.90	p < 0.001**
Group A vs Group C	0.76	p = 0.790
Group A vs Group D	4.70	p < 0.001**
Group B vs Group C	5.66	p < 0.001**
Group B vs Group D	0.20	p = 0.995
Group C vs Group D	5.46	p < 0.001**

Table 4: Comparison of Chinthickness [Pog –Pog'] (in mm) between four groups respectively

Pog –Pog'	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	6.93	0.98	F = 59.76	p <0.001**
Group B (Hypodivergent Class I)	9.13	1.16		
Group C (Hyperdivergent Class II)	6.33	1.29		
Group D (Hypodivergent Class II)	9.76	1.25		

Table 4 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	2.20	p < 0.001**
Group A vs Group C	0.60	p =0.205
Group A vs Group D	2.83	p < 0.001**
Group B vs Group C	2.80	p < 0.001**
Group B vs Group D	0.63	p =0.166
Group C vs Group D	3.43	p < 0.001**

p>0.05 – not significant *p<0.05 – significant **p<0.001 – highly significant

A patient with a short chin throat length is indicative of retrusive mandible and usually seen in vertical growth. A long chin throat length is indicative of protrusive mandible and low angle patients according to Johan P. Reyneke and Carlo Ferretti (2012).[1] A similar finding was seen, where the chin throat length was less in skeletal Class I and skeletal Class II hyperdivergent samples than the skeletal Class I and skeletal Class II hypodivergent. This suggests that patients with a short chin throat length have hyperdivergent growth pattern. A long, straight chin throat length is indicative of horizontal growth pattern. Often a mandibular setback is necessary with chin augmentation to balance lips with chin and maintain throat length. Suction lipectomy is a useful adjunct for controlling submental sag with setbacks or when isolated fat accumulation is present. Johan P. Reyneke and Carlo Ferretti (2012).[1] A recent study by Ramzi Haddid and Joseph Gafari (2017),[2] found there was a significant difference between the chin throat dimension among skeletal Class I, skeletal Class II and skeletal Class III subject.

In the selection of the treatment methods the soft tissue chin thickness is thinner in hyperdivergent facial patterns, apparently in contrast to Pog and the thickness is more in hypodivergent. This differential thickness implies that it is possible to vertically grow hard tissues impinging on the inferior soft-tissue envelope in patients with severe hyperdivergence and to plan for genioplasty in such patients when more advancement of the chin might be needed to compensate for the increased vertical height according to Macari AT, Hanna AE; (2014).[3] In the study there was

Table 5: Comparison of Chin thickness [Gn – Gn'] (in mm) between four groups respectively

Gn – Gn'	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	4.06	0.52	F = 59.51	p <0.001**
Group B (Hypodivergent Class I)	6.76	1.67		
Group C (Hyperdivergent Class II)	3.73	0.63		
Group D (Hypodivergent Class II)	6.26	1.11		

Table 5 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN difference	p value, Significance
Group A vs Group B	2.70	p < 0.001**
Group A vs Group C	0.33	p =0.636
Group A vs Group D	2.20	p < 0.001**
Group B vs Group C	3.03	p < 0.001**
Group B vs Group D	0.50	p = 0.287
Group C vs Group D	2.53	p < 0.001**

p>0.05 – not significant *p<0.05 – significant **p<0.001 – highly significant

Table 6: Comparison of Chin thickness [Me – Me'] (inmm) between four groups respectively

Me-Me'	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	4.1	0.8	F =39.39	p <0.001**
Group B (Hypodivergent Class I)	6.26	1.31		
Group C (Hyperdivergent Class II)	3.9	1.09		
Group D (Hypodivergent Class II)	6.16	1.20		

Table 6 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	2.16	p < 0.001**
Group A vs Group C	0.20	p =0.90
Group A vs Group D	2.06	p < 0.001**
Group B vs Group C	2.36	p < 0.001**
Group B vs Group D	0.10	p =0.986
Group C vs Group D	2.26	p < 0.001**

a significant difference, where the Me-Me', Gn-Gn' and Pog-Pog' was less in skeletal Class I and skeletal Class II hyperdivergent samples than the skeletal Class I and skeletal Class II hypodivergent. There was no significant difference between skeletal Class I and skeletal Class II hyperdivergent malocclusion and between skeletal Class I and skeletal Class II hypodivergent group. Compared to the study of Macari AT, Hanna AE; (2014)[3] the conducted study shows a significant difference in Pog-Pog'. The main contribution of this study was the association between mandibular vertical divergence and soft tissue chin thickness. Patients with greater MP/SN angle have thinner soft tissue chin and thicker in hypodivergent as seen in Tables 4, 5 and 6 . This finding suggests that as the vertical expansion of the skeletal tissues increases, it impinges on the thickness of a soft tissue that no longer displaces in a corresponding ratio of 1:1. This ratio has been reported in clinically normal development and after orthognathic surgery of the mandible and chin. According to Subtenly (199)[4] the soft tissue landmarks of the chin region follow respective hard tissue.

Significant relationships between the pharyngeal structures and both dentofacial and craniofacial structures have been reported by Atia Elwareth, Elrazik Yousif (2015).[5] Hyper-divergent patients may lead to narrower anteroposterior dimensions of the airway. This result was associated with vertical growth pattern and with obstruction of the upper and lower pharyngeal airways and also associated with mouth breathing and Class II malocclusion according to Atia Elwareth, Elrazik Yousif (2015).[5] The conducted study was performed in reference to lower

Table 7: A: Comparison of Chin throat length (in mm) between four groups respectively

Chin Throat Length (in mm)	MEAN	S.D	ANOVA 'F' Test	p value, Significance
Group A (Hyperdivergent Class I)	34.4	3.96	F =43.39	p <0.001**
Group B (Hypodivergent Class I)	44.26	6.37		
Group C (Hyperdivergent Class II)	33.36	3.54		
Group D (Hypodivergent Class II)	44.56	5.82		

Table 7 B: Tukey's post hoc test to find pairwise comparisons

Comparisons	MEAN Difference	p value, Significance
Group A vs Group B	9.86	p < 0.001**
Group A vs Group C	1.03	p = 0.859
Group A vs Group D	10.16	p < 0.001**
Group B vs Group C	10.90	p < 0.001**
Group B vs Group D	0.30	p = 0.996
Group C vs Group D	11.20	p < 0.001**

p>0.05 – not significant *p<0.05 – significant **p<0.001 – highly significant

airway length, which was less in skeletal Class I and skeletal Class II hyperdivergent samples than the skeletal Class I and skeletal Class II hypodivergent. There was no significant difference between skeletal Class I and skeletal Class II hyperdivergent malocclusion except skeletal Class I and skeletal Class II hypodivergent group as seen in Table 1 and Figure A. Abu Joseph (2000)[6] and Flores-Blancas, A. P., Carruitero, M. J., & Flores-Mir, C. (2017)[7] found that there were narrow airway dimensions in hyperdivergent patients and the contributing factors are maxillary or mandibular retrognathism and also a downward rotation of the mandible.

The mandibular dimension compensations are usually seen in cases with hyperdivergent growth pattern where the ramus height and mandibular body compensates along with the symphysis which is observed according to Peter H.Buschang (2013).[8] This included the changes with respect to skeletal Class I and skeletal Class II hypodivergent and hyperdivergent cases so as to compare the changes occurring between the mandibular dimensions. In the study there was a significant difference, where the ramus height (Co-Go) and mandibular body (Go-Gn) were less in skeletal Class I and skeletal Class II hyperdivergent samples than the skeletal Class I and skeletal Class II hypodivergent. There was no significant difference between skeletal Class I and skeletal Class II hyperdivergent malocclusion and between skeletal Class I and skeletal Class II hypodivergent group seen in Tables 2, 3 and Figure B, C. According to Betzenberger D, Ruf S, Pancherz H (1999),[9] Alhammadi M. S. (2019),[10] Allan G. Brodie (1953),[11] Schendel, Stephen A. et al,[12] in high angle morphology mandibular hyperdivergence is compensated for posterior and has an effect on incisor position and vertical jaw relation. Karlsen (1997)[13] suggested that when there is an increase in posterior facial height with the forward rotation of mandible and increased anterior facial height was associated with an increase in corpus length of the mandible.

The findings observed in the study will give more precise information with an increase in the sample size for the changes seen in hypodivergent and hyperdivergent patients with skeletal Class I and Class II patterns.

4.1. Clinical aspect

The study attempts to change the perception of the clinicians concerning diagnosis and treatment planning. The clinicians should note the probability of the changes that may occur in the dimensions of the parameters such as chin throat length, lower airway space, chin thickness, mandibular ramus and mandibular body in the patient with various divergence and skeletal patterns. For example, consider a patient seeking orthodontic treatment with hyperdivergent skeletal Class II pattern, before considering the dental treatment plan clinician should consider the dimensions of the mandibular ramus and the mandibular body, the chin thickness, the chin throat length and the lower airway space which will be less according to the study. Hence the treatment plan must be such that it will not hinder the function and esthetics of the patient.

5. Limitation and Future Prospects

1. Larger sample size provide more accurate mean values. It detects outliers that could skew the data in a smaller sample and provide a smaller margin of error.
2. The major limitation of the present study was that, the samples were with 2-dimensional radiological method.
3. The 2-dimensional radiographic representation of the region of the mandibular symphysis is misleading due

to the intrinsic errors such as superimposition of the anatomic structures.

4. Identifying single dental elements is difficult due to magnification errors of the x-ray.
5. The use of the computed tomography can achieve accurate evaluation of the dimensions of the mandible.
6. Cone-beam computed tomography yields high definition images of the teeth and bone at a far lower dosage of radiation.
7. New avenues for the further research can be done using Cone-beam computed tomography systems.

6. Conclusion

The study concludes that the lower airway space, mandibular ramus, mandibular body, soft tissue chin thickness, chin throat length was less in skeletal Class I and skeletal Class II hyperdivergent samples than the skeletal Class I and skeletal Class II hypodivergent.

1. There was no significant difference between the measures of the skeletal Class I and the skeletal Class II hyperdivergent malocclusion also no significant between the measures of the skeletal Class I and the skeletal Class II hypodivergent group except for lower airway space where significant difference was seen.

7. Source of Funding

None.

8. Conflict of Interest

The authors declare no conflict of interest.

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Author biography

Vighanesh Kadam, Resident Orthodontist https://orcid.org/0000-0002-6979-8060

Hrushikesh Aphale, Professor

Sunil Kumar Nagmode, Professor and HOD

Vasant Pawar, Professor

Kunal Patil, Reader

Deepak Sahane, Lecturer

Vivek Shinde, Lecturer

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