Evaluation Of Mandibular Morphology In Different Facial Types- A Retrospective Cephalometric Study

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Abstract-This study aimed to assess and compare mandibular morphology among different facial patterns in individuals with skeletal Class II malocclusion using lateral cephalograms. This retrospective study was performed on 150 patients aged 16–25 years diagnosed with skeletal Class II malocclusion. Based on the Frankfort Mandibular Plane Angle (FMA), they were categorized into three groups of 50 patients each: Group I – Normodivergent (FMA 23–27°), Group II – Hypodivergent (FMA <23°), and Group III – Hyperdivergent (FMA >27°). Pretreatment lateral cephalograms were evaluated to analyze mandibular morphology in these groups. The results of the study showed that Hyperdivergent group showed notably increased values for the Mandibular plane angle, Gonial angle, Y-axis angle, Mandibular anterior alveolar basal height (MdAABH), Antegonial notch depth (AN), and Symphysis height (SH). However, decreased measurements were observed for the SNA angle, SN-Pog angle, Symphysis depth (SD), Ramus height (RH), and Ramus width (RW). In contrast Hypodivergent showed opposite tendency while Normodivergent showed well balanced mandible. The study concluded that variations in facial types are closely associated with mandibular morphology and dentoalveolar characteristics. Recognizing these relationships is valuable in both diagnosis and treatment of malocclusion cases.

Keywords—
Skeletal Class II, Mandibular morphology, Normodivergent, Hypodivergent, Hyperdivergent.

I. INTRODUCTION

Class II malocclusion is among the most common problem encountered in orthodontic practice. Recognizing facial types i.e Normodivergent, Hypodivergent, and Hyperdivergent in individuals with skeletal Class II malocclusion is essential, as both the direction and magnitude of growth influence the orthodontic biomechanics required. With the introduction of radiographic cephalometry, greater emphasis has been placed on understanding variations in facial patterns. This has enabled the evaluation of facial types in relation to malocclusion and skeletal structure. While predicting overall craniofacial growth remains ideal, assessing mandibular growth is particularly valuable for diagnosis, treatment planning, and achieving harmonious dentofacial proportions [1]. Bjork, through his implant studies on craniofacial growth, highlighted that morphological differences in the mandible arise due to clockwise or counterclockwise rotation, and that these rotational patterns can be anticipated by analyzing structural changes [2]. Accordingly, this study was undertaken to assess and compare the mandibular morphology across various facial types in individuals with skeletal Class II malocclusion.

II. MATERIALS AND METHODS

This study was carried out using patient records and data collected from individuals visiting the Department of Orthodontics and Dentofacial Orthopaedics at the National Dental College and Hospital, Dera Bassi, Punjab. Ethical clearance for the research was obtained from the Institutional Ethical Committee of the same institution. A total of 150 students aged 16-25 years were equally divided into three groups based on their facial types by using Frankfort mandibular plane angle.

- Group I: Normodivergent facial type (FMA 23–27°).
- Group II: Hypodivergent facial type (FMA <23°).
- Group III**:** Hyperdivergent facial type (FMA >27°).

Inclusion criteria:

- Patients with skeletal Class II malocclusion.
- Patients having chronological age of 16-25 years.
- No previous history of orthodontic treatment.
- No previous history of trauma or surgery in the dentofacial region

Exclusion criteria:

- Jaw asymmetry.
- TMJ abnormality.
- Craniofacial syndrome.
- Cleft lip and palate.
- Anterior skeletal open bite.

Various landmarks used in the study (Figure1):

1. Sella Turcica (S) – It is the center of Pituitary fossa or Sella Turcica.
2. Nasion (N) – It is a point from where frontonasal and internasal sutures meet in the midline.
3. Orbitale (Or) - The lowest point on the inferior outline of the bony orbit.
4. Porion (Po) – The superiormost point of the external auditory meatus.
5. Articular (Ar) – It is the intersection point of the inferior surface of the cranial base and the posterior surfaces of the necks of the condyles of mandible.
6. Condylion (Cd) - The most superior point on the head of condyle.
7. Point B (Supramentale) - It is the deepest point in the midline between alveolar crest of mandible and mental process.
8. Gonion (Go) - It is a constructed point at the junction of Ramal plane and Mandibular plane.
9. Gnathion (Gn) - The most antero-inferior point on the Symphysis of chin.
10. Pogonion (Pog) -The most anterior point of the bony chin in the median plane.
11. Menton (Me) - The most inferior point in the midline on the mandibular symphysis.
12. R - The point in the anterior border of the Ramus of the mandible at the height of Palatal plane.
13. R'- The point in the posterior border of the Ramus of the mandible at the height of the Palatal plane.
14. Anterior convexity point (ACP) – It is the point of greatest convexity along the anterior-inferior border of the mandible.
15. Inferior Gonion (IGo) – It is the point of greatest convexity along the posterior- inferior border of mandible.
16. Antegonial notch (AN) – It is the point of the deepest concavity between ACP and IGo.

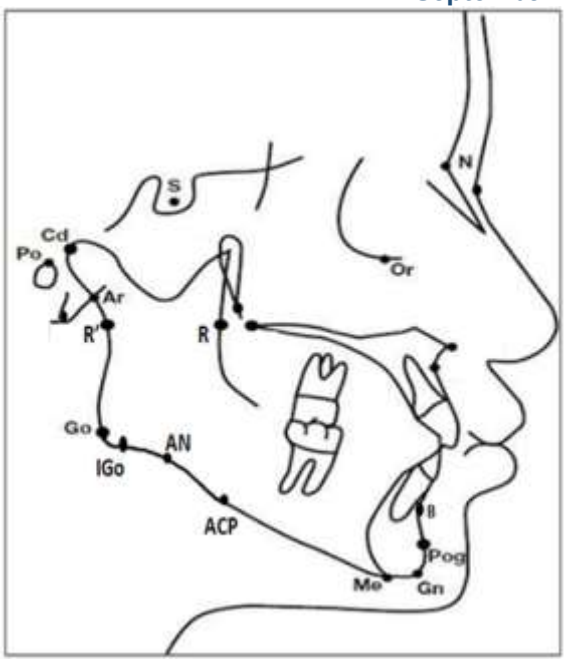

Fig.1: Various landmarks used in the study.

Reference planes used in the study:

1. Sella-Nasion Plane (S-N) - Line that joins Sella Turcica and Nasion.
2. Frankfort Horizontal Plane (Po-Or) - Line that joins Porion and Orbitale.
3. Mandibular Plane (Go-Me) - Line joining Gonion and Menton.

Varoius linear and angular parameters used in the study (Figure- 2):

1. SNB – It is the angle between S, N and Point-B.
2. SN-Pog - It is the angle between S, N and Pog.
3. Y -Axis- It is the angle between N, S and Gn.
4. Gonial angle (Ar-Go-Me) -The angle formed between Ar, Go and Me.
5. SN plane to Mandibular plane – The angle that is formed between S-N plane and Mandibular plane (Go-Me).
6. Antegonial notch depth (AN) - The linear distance that is measured from the greatest point of convexity in Antegonial notch to the line connecting anterior convexity point (ACP) with inferior gonion (IGo) along a line perpendicular to ACP-IGo.
7. Symphysis height (SH) - The linear distance that is measured between Infradentale and Menton point.
8. Symphysis depth (SD)- The distance between pogonion and the most posterior wall of symphysis.
9. Mandibular anterior alveolar and basal height (MdAABH) - The linear distance that is measured between the midpoint of the alveolar meatus of the mandibular central incisor and intersection between the symphyseal surface and mandibular alveolar axis.
10. Mandibular posterior alveolar and basal height (MdPABH) - The perpendicular distance between the midpoint of the alveolar meatus of the mandibular first molar and the mandibular plane.
11. Ramus width (RW) - The linear distance that is measured between R and R' points.
12. Ramus height (RH) - The linear distance between Ar and Go.
13. Mandibular length (Cd-Gn) - The linear distance between Cd and Gn.

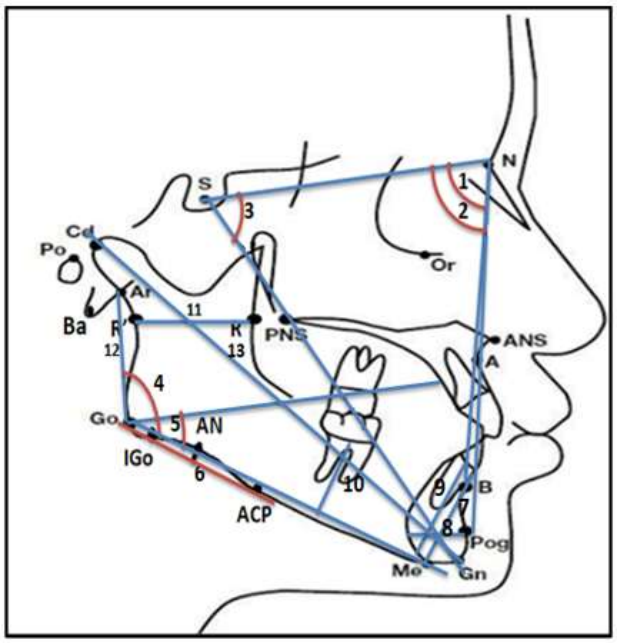

Fig. 2**:** Various parameters for the evaluation of Mandibular morphology.

Statistical Analysis

All the parameters were analyzed using SPSS software version 23.0. A One-Way ANOVA test was applied to compare the three groups, followed by Post-Hoc analysis to identify intergroup differences. The level of significance was set at 5%. Data distribution and normality of variables were assessed using the Shapiro–Wilk test.

III. RESULTS

SNB and SN-Pog angles showed significant variation ($p = 0.001$), with the highest values in Hypodivergent and lowest in Hyperdivergent groups, indicating mandibular retroposition with respect to cranial base in the Hyperdivergent group as shown in (Table 1). When intergroup comparison was done using Post-hoc significant differences were observed between Normodivergent and Hypodivergent group and between Hypodivergent and Hyperdivergent group. Non-significant results were observed between Normodivergent and Hypodivergent group ($p > 0.05$) (Table 2). Y-Axis angle was also significantly elevated in Hyperdivergent individuals ($p = 0.001$), reflecting increased vertical growth. Gonial angle and SN-Go-Me (mandibular plane angle) were highest in Hyperdivergent and lowest in Hypodivergent groups, with all intergroup comparisons showing significance ($p < 0.05$), supporting a more vertical growth tendency in Hyperdivergent patterns as shown in (Table 1, 2)**.** Notable differences were observed in Antegonial Notch (AN), Symphysis Height (SH), Symphysis Depth (SD), Mandibular Anterior Alveolar and Basal Height (MdAABH), Ramus Width (RW), and Ramus Height (RH) across facial types ($p=0.001$). The Hyperdivergent group exhibited deep Antegonial notch (AN), greater Symphysis height (SH), and increased Mandibular anterior alveolar basal height (MdAABH), while the Hypodivergent group showed greater SD, broader RW, and longer RH. Significantly, Post hoc analysis revealed intergroup differences primarily between Hypodivergent and Hyperdivergent groups. In contrast, Mandibular Posterior Alveolar and Basal Height (MdPABH) and effective mandibular length (Cd-Gn) did not show significant changes among groups, indicating relative consistency regardless of vertical pattern as shown in (Table 3, 4).

Table 1: Intergroup comparison among groups with respect to angular skeletal parameter using One Way ANOVA test.

	Group	No. of Patients	Mean	Standard Deviation	Standard error	P value
SNB (deg)	Normodivergent	50	77.6000	3.46999	0.49073	0.001 *
	Hypodivergent	50	78.1400	4.16011	0.58833	
	Hyperdivergent	50	75.5200	3.35176	0.47401	
SN-Pog (deg)	Normodivergent	50	78.9600	3.55688	0.50302	0.001 *
	Hypodivergent	50	79.5000	4.13669	0.58502	
	Hyperdivergent	50	75.9400	3.54798	0.50176	
Y-Axis (deg)	Normodivergent	50	66.9600	3.52229	0.49813	0.001 *
	Hypodivergent	50	64.8000	3.53986	0.50061	
	Hyperdivergent	50	70.2600	3.92693	0.55535	
Ar-Go-Me (deg)	Normodivergent	50	123.10	9.70851	1.37299	0.001 *
	Hypodivergent	50	119.94	4.63091	0.65491	
	Hyperdivergent	50	130.06	5.90887	0.83564	
SN-GoMe (deg)	Normodivergent	50	30.9200	3.61313	0.51097	0.001 *
	Hypodivergent	50	25.9600	3.96392	0.56058	
	Hyperdivergent	50	37.7400	4.53922	0.64194	

Table 2: Intergroup comparison of angular skeletal parameter in different facial types using Pos Hoc test.

	Intergroup Comparison		Mean Difference	Standard Error	P value
SNB (deg)	Normodivergent	Hypodivergent	-0.54000	0.73559	0.464
	Normodivergent	Hyperdivergent	**2.08000***	0.73559	**0.005 ***
	Hypodivergent	Hyperdivergent	**2.62000***	0.73559	**0.000 ***
SN-Pog (deg)	Normodivergent	Hypodivergent	-0.54000	0.75146	0.474
	Normodivergent	Hyperdivergent	**3.02000***	0.75146	**0.000 ***
	Hypodivergent	Hyperdivergent	**3.56000***	0.75146	**0.000 ***
Y-Axis (deg)	Normodivergent	Hypodivergent	**2.16000***	0.73356	**0.004 ***
	Normodivergent	Hyperdivergent	**-3.30000***	0.73356	**0.000 ***
	Hypodivergent	Hyperdivergent	**-5.46000***	0.73356	**0.000 ***
Ar-Go-Me (deg)	Normodivergent	Hypodivergent	**3.16000***	1.41711	**0.027 ***
	Normodivergent	Hyperdivergent	**-6.96000***	1.41711	**0.000 ***
	Hypodivergent	Hyperdivergent	**10.12000***	1.41711	**0.000 ***
SN-Go-Me (deg)	Normodivergent	Hypodivergent	**4.96000***	0.81135	**0.000 ***
	Normodivergent	Hyperdivergent	**-6.82000***	0.81135	**0.000 ***
	Hypodivergent	Hyperdivergent	**11.78000***	0.81135	**0.000**

Table 3: Intergroup comparison among groups with respect to linear skeletal parameter using One Way ANOVA test.

	Group	No. of Patients	Mean	Standard Deviation	Standard. Error	P value
AN (mm)	Normodivergent	50	0.9100	0.74703	0.10565	0.001 *
	Hypodivergent	50	0.7500	0.69437	0.09820	
	Hyperdivergent	50	1.1800	0.66823	0.09450	
SH (mm)	Normodivergent	50	31.4400	3.35127	0.47394	0.001 *
	Hypodivergent	50	30.6400	3.63520	0.51410	
	Hyperdivergent	50	33.3400	2.87573	0.40669	
SD (mm)	Normodivergent	50	12.4200	1.67624	0.23706	0.001 *
	Hypodivergent	50	13.0000	1.57791	0.22315	
	Hyperdivergent	50	11.7800	2.46021	0.34793	
MdAABH (mm)	Normodivergent	50	31.8000	3.50510	0.49570	0.001 *
	Hypodivergent	50	31.3400	3.76130	0.53193	
	Hyperdivergent	50	33.7200	2.71834	0.38443	
MdPABH (mm)	Normodivergent	50	23.2800	3.19464	0.45179	0.339
	Hypodivergent	50	23.8100	3.59548	0.50848	
	Hyperdivergent	50	24.1800	2.24690	0.31776	
RW (mm)	Normodivergent	50	28.9400	3.50748	0.49603	0.001 *
	Hypodivergent	50	29.9800	3.04048	0.42999	
	Hyperdivergent	50	27.4400	2.73421	0.38668	
RH (mm)	Normodivergent	50	44.0200	6.51056	0.92073	0.001 *
	Hypodivergent	50	47.7600	6.60723	0.93440	
	Hyperdivergent	50	40.3800	7.00114	0.99011	
Cd-Gn (mm)	Normodivergent	50	103.44	5.51495	0.77993	0.696
	Hypodivergent	50	104.00	7.34847	1.03923	
	Hyperdivergent	50	102.76	8.63262	1.23323	

Table 4: Intergroup comparison of linear skeletal parameter in different facial types using Pos Hoc test.

	Intergroup Comparison		Mean Difference	Standard Error	P value
AN (mm)	Normodivergent	Hypodivergent	-0.16000	0.14079	0.258
	Normodivergent	Hyperdivergent	-0.27000	0.14079	0.057
	Hypodivergent	Hyperdivergent	**-0.43000**	0.14079	**0.003 ***
SH (mm)	Normodivergent	Hypodivergent	0.80000	0.66046	0.228
	Normodivergent	Hyperdivergent	**-1.90000**	0.66046	**0.005 ***
	Hypodivergent	Hyperdivergent	**-2.70000**	0.66046	**0.000 ***
SD (mm)	Normodivergent	Hypodivergent	-0.58000	0.38905	0.138
	Normodivergent	Hyperdivergent	0.64000	0.38905	0.102
	Hypodivergent	Hyperdivergent	**1.22000**	0.38905	**0.002 ***
MdAABH (mm)	Normodivergent	Hypodivergent	0.46000	0.67154	0.494
	Normodivergent	Hyperdivergent	**-1.92000**	0.67154	**0.005 ***
	Hypodivergent	Hyperdivergent	**-2.38000**	0.67154	**0.001 ***
MdPABH (mm)	Normodivergent	Hypodivergent	-0.53000	0.61299	0.389
	Normodivergent	Hyperdivergent	-0.90000	0.61299	0.144
	Hypo divergent	Hyperdivergent	-0.37000	0.61299	0.547
RW (mm)	Normodivergent	Hypodivergent	-1.04000	0.62207	0.097
	Normodivergent	Hyperdivergent	**1.50000**	0.62207	**0.017 ***
	Hypodivergent	Hyperdivergent	**2.54000**	0.62207	**0.000 ***
RH (mm)	Normodivergent	Hypodivergent	**-3.74000**	1.34193	**0.006 ***
	Normodivergent	Hyperdivergent	**3.64000**	1.34193	**0.007 ***
	Hypodivergent	Hyperdivergent	**7.38000**	1.34193	**0.000 ***
Cd-Gn (mm)	Normodivergent	Hypodivergent	-1.24490	1.46110	0.396
	Normodivergent	Hyperdivergent	-0.68490	1.46110	0.640
	Hypodivergent	Hyperdivergent	0.56000	1.45370	0.701

IV. DISCUSSION

Group selection in this study was based on facial types determined by the FMA angle. The selected age range of 16–25 years represents a relatively stable phase of craniofacial growth and development. During this period, the influence of active growth is minimal, and the presence of permanent dentition eliminates the variability associated with the mixed dentition stage. This

perspective, supported by Altemus [3], highlights that a consistent skeletal pattern is established within this age group, with limited subsequent changes.

In the current study SNB and SN-Pog angles were highest in the Hypodivergent group and lowest in the Hyperdivergent group, indicating mandibular retropositioning in the latter. This was due to an increased SN:MP angle, causing downward and backward mandibular rotation, along with a reduced horizontal mandibular length in Hyperdivergent group. Conversely, the Hypodivergent group showed a forward-positioned mandible due to a lower SN:MP angle and greater horizontal mandibular length. These findings align with those of Opdebeeck and Bell (1978) [4]**.** Significant intergroup differences in Y-Axis values were observed, with the Hyperdivergent group showing a more vertical growth pattern. This aligns with Rakosi's findings, where values above 66° indicate vertical growth pattern and posterior mandibular positioning due to clockwise rotation, while values below 66° reflect horizontal growth and anterior mandibular positioning due to anticlockwise rotation [5].

In this study, the Gonial angle (Ar-Go-Me) indicated that individuals in the Hyperdivergent group exhibited a more vertical growth pattern. This was attributed to reduced posterior facial height combined with an increased lower anterior facial height, leading to downward and backward mandibular rotation. Numerous investigators, Opdebeeck [3], Sassouni et al. [6], Subtelny [7], Field et al. [8] have also indicated similar results that an obtuse gonial angle was associated with a skeletal open bite while a relatively small angle was associated with a deep bite. For SN-Go-Me (Mandibular plane angle) Hyperdivergent group showed a more steeper mandibular plane with respect to cranial base in Hyperdivergent group**.** The result of the present study was in accordance with Rakosi, who stated that the increase in mandibular plane in Hyperdivergent group is because of downward rotation of growth of mandible with respect to cranial base and least value in Hypodivergent group was because of anticlockwise rotation of mandible with respect to cranial base [5].

The Hyperdivergent group showed a deeper antegonial notch (AN) than the Hypodivergent group, indicating reduced mandibular growth in Hyperdivergent group. This depth reflects reduced rate of mandibular growth and bone remodeling along the lower border, particularly below the gonial angle. These findings align with implant studies by Bjork [2], Singer [9], who also reported deeper AN in Hyperdivergent subjects. Intergroup comparison showed that Hyperdivergent individuals had increased symphysis height (SH) and reduced symphysis depth (SD), while Hypodivergent individuals showed the opposite. This reflects a compensatory adaptation to maintain incisal function, with vertical enlargement and labiolingual narrowing of the symphysis. The symphysis size and shape play a key role in treatment planning, as larger symphyses allow for greater incisor protrusion and may support non-extraction approaches. These findings align with those of Mangla et al. (2011) [1] and Roy et al. (2012) [10]**.** The Hyperdivergent group showed increased anterior alveolar and basal height compared to the Hypo- and Normodivergent groups, likely due to compensatory mandibular incisal alveolar growth that helps maintain functional balance by retroclining and vertically elongating the lower incisors to counteract open bite tendencies. These findings align with those of Roy et al. (2012) [10] and Ceylan et al. (2001) [11]. However, mandibular posterior alveolar and basal height (MdPABH) showed no significant variation across facial types. This finding was consistent with Roy et al. (2012) [10], but differing from Isaacson et al. (1971) [12], who reported increased MdPABH in Hyperdivergent individuals due to greater SN-MP angle and molar height.

The present study revealed that ramus height (RH) and width (RW) were greatest in the Hypodivergent group, followed by the Normodivergent and Hyperdivergent groups. The larger ramus dimensions in Hypodivergent individuals may be attributed to their stronger and more active masticatory muscles. Increased muscular activity generates greater forces on the ramus, stimulating bone growth and contributing to enhanced ramus height and width. The lateral flaring of the gonial process reflects strong masseter activity, resulting in increased ramus height, while the broad ramus and prominent coronoid process suggest strong temporalis muscle function. These findings are consistent with the results reported by Mangla et al. (2011) [1] and Sassouni (1969) [13]. In contrast, no significant difference was observed in Mandibular (Cd-Gn) length across groups in this study. This outcome differs from the findings of Roy et al. (2012) [10], who reported a comparatively shorter effective mandibular length in Hyperdivergent individuals relative to Normodivergent and Hypodivergent groups, attributing it to reduced mandibular growth and the presence of a pronounced antegonial notch.

V. CLINICAL SIGNIFICANCE

Traditionally, orthodontic treatment has focused largely on addressing anteroposterior discrepancies in the dental arches. However, evaluating mandibular morphology is equally important, as it provides valuable insight into growth prediction and directly influences treatment planning. Clinical decisions such as tooth extraction, anchorage requirements, biomechanics applied, and the duration of retention are all guided by an individual's growth pattern.

The morphology of the mandibular symphysis is particularly significant in orthodontic assessment. A larger symphysis allows greater incisor protrusion to be esthetically acceptable, favoring a non-extraction approach. In contrast, patients with increased symphysis height and a small chin are more likely to require extractions to resolve arch length discrepancies. In Hyperdivergent individuals, elevated posterior mandibular dental height necessitates orthodontic strategies, such as intrusion, to control vertical dimension.

Growth pattern also affects muscle efficiency. An increase in gonial angle, often seen in Hyperdivergent patients, reduces the mechanical advantage of the adductor muscles, whereas greater ramus height enhances masseter muscle efficiency, as typically observed in Hypodivergent patients. Consequently, Hypodivergent individuals have a stronger mechanical advantage compared to Hyperdivergent counterparts. Surgical interventions aimed at correcting facial imbalances can also impact muscle function; for example, mandibular advancement tends to reduce the efficiency of the adductor muscles.

Anchorage preservation is particularly critical in Hyperdivergent patients, while Hypodivergent individuals require stronger extrusive forces to counteract their musculature's mechanical advantage. In vertical facial types with weaker musculature, careful control of sagittal changes is essential to counter mesial migration of the dentition. Additionally, the short ramus height and skeletal open bite often associated with Hyperdivergent cases make isolated mandibular ramus surgery ineffective. Such procedures cause ramus elongation and stretching of the pterygoid sling muscles, increasing the risk of relapse. Therefore, combining ramus correction with maxillary intrusion is recommended to minimize unfavourable outcome.

VI. CONCLUSION

- The Hypodivergent group demonstrated higher SNB and SN-Pog angles compared to the Hyperdivergent and Normodivergent groups.
- The Hyperdivergent group showed increased Y-axis and gonial angles, whereas the Hypodivergent group exhibited the opposite features. The Normodivergent group presented average values with minimal mandibular rotation.
- Hyperdivergent individuals displayed greater mandibular anterior alveolar basal height (MdAABH), deeper antegonial notch (AN), increased symphysis height (SH), greater symphysis depth (SD) reduced ramus height (RH), and increased ramus width (RW). In contrast, Hypodivergent patients demonstrated reverse trends, while Normodivergent cases showed average values. Parameters such as mandibular posterior alveolar basal height (MdPABH) and effective mandibular (Cd-Gn) length remained consistent across all facial types, showing no significant variation with divergence pattern.

VII. ABBREVATIONS

AN-Antegonial notch, Cd- Condylion, SH- Symphysis height, SD- Symphysis depth, RW- Ramus width, RH- Ramus height, MdAABH- Mandibular anterior alveolar and basal height, MdPABH- Mandibular posterior alveolar basal height, Gn- Gnathion, Me-Menton, Go-Gonion, Ar-Articular, Or-Orbitale, Po-Porion, S-Sella, N- Nasion.

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