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CORRELATION OF SYMPHYSEAL ANGLE WITH VERTICAL SKELETAL PARAMETERS IN SKELETAL CLASS I MALOCCLUSION: A CEPHALOMETRIC STUDY

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ABSTRACT
Multiple myeloma (MM) is a clinically and biologically heterogeneous plasma cell malignancy, representing the second most common hematologic cancer. Recent years have witnessed transformative advances in molecular diagnostics, risk stratification, and therapeutic modalities, leading to significantly improved survival outcomes. This review provides a comprehensive update on the epidemiology, molecular pathogenesis, diagnostic criteria, staging systems, and contemporary treatment paradigms of MM. Emphasis is placed on the integration of next-generation sequencing, fluorescence in situ hybridization (FISH), and minimal residual disease (MRD) monitoring into clinical practice. The advent of proteasome inhibitors, immunomodulatory drugs, monoclonal antibodies, chimeric antigen receptor (CAR) T-cell therapy, and bispecific antibodies has redefined MM management. Despite these advances, high-risk cytogenetic subgroups continue to pose therapeutic challenges. This manuscript highlights the shift toward personalized medicine in MM, discusses current clinical challenges, and outlines future research directions aimed at achieving durable remissions and potential cure.

KEYWORDS: Multiple myeloma, MGUS, cytogenetics, proteasome inhibitors, immunomodulatory drugs, CAR-T therapy, minimal residual disease, personalized medicine.

INTRODUCTION
One of the most important aspects of orthodontic treatment planning is making an accurate diagnostic of craniofacial growth pattern. Among skeletal differences, vertical disharmony has a considerable impact on facial aesthetics, occlusal stability, biomechanics, and long-term prognosis. Identifying the vertical growth pattern is thus critical for determining anchoring management, extraction options, and retention strategies. Even in skeletal Class I malocclusion, vertical differences might affect treatment outcomes if not adequately diagnosed.[1]

Orthodontists commonly use cephalometric indices like the mandibular plane angle, Jarabak ratio, lower anterior face height, and Y-axis measurements to assess vertical skeletal relationships.[2] The SN-GoGn angle and Jarabak ratio are notable for predicting mandible growth direction, with an increased mandibular plane angle indicating vertical growth and a decreased angle suggesting horizontal growth.[3] A higher Jarabak ratio correlates with posterior facial height and horizontal growth, while a smaller ratio reflects vertical growth. However, these measurements primarily evaluate global skeletal relationships and may not adequately represent localized mandibular adaptation during growth.[4]

The mandible continually remodels in response to functional needs, muscle pressures, and occlusal loads. The mandibular symphysis is a very adaptable area. Its appearance is controlled by mandibular rotation, dentoalveolar compensation, and soft-tissue balance. Forward mandibular rotation causes bone deposition along the inferior border, resulting in a larger and upright symphysis, while backward rotation results in a narrower and inclined symphysis.[5]

The symphyseal region is vital in orthodontics as it sets the safe limits for incisor movement, with its thickness and inclination influencing retraction or proclination without risking dehiscence or fenestration. Excessive movement beyond the alveolar envelope risks periodontal health and potential relapse, making morphological evaluation essential before treatment.[7] Recent concepts highlight structural indicators over mere dimensional measurements for growth prediction, suggesting that the symphyseal angle can provide key diagnostic insights concerning vertical growth tendencies and localized remodeling, in contrast to traditional cephalometric parameters.[8]

Previous research has shown that horizontal growers have thicker alveolar bone and wider symphyseal morphology, while vertical growers have an elongated facial pattern and narrow symphysis. However, most studies measured symphyseal breadth and thickness rather than angular orientation. Very little study has studied the association between symphyseal angulation and vertical skeletal characteristics.[10]

Skeletal Class I malocclusion serves as a useful model for examining vertical relationships due to minimal sagittal jaw discrepancies and independent assessment of vertical characteristics.[11] This study investigates the correlation between the symphyseal angle and specific vertical skeletal parameters, such as the Jarabak ratio and SN–GoGn angle, in individuals with skeletal Class I malocclusion. Establishing this correlation could enhance diagnostic accuracy and position the symphyseal angle as a valuable supplemental diagnostic tool in orthodontic treatment planning.

MATERIALS AND METHODS

The present investigation was designed as an in-vivo observational cephalometric study comprising 45 subjects diagnosed with skeletal Class I malocclusion. Skeletal Class I relationship was confirmed using the ANB angle (0°–4°).

The sample was stratified into three vertical growth pattern groups

Horizontal growers (n = 15)

Average growers (n = 15)

Vertical growers (n = 15)

Inclusion criteria included subjects with fully erupted permanent dentition, no history of orthodontic treatment, and high-quality standardized lateral cephalograms with clearly identifiable anatomical landmarks.

Subjects presenting with skeletal Class II or Class III malocclusion, craniofacial syndromes, facial asymmetry, prior orthodontic therapy, or poor-quality radiographs were excluded.

Written informed consent was obtained from all participants prior to enrollment.

Standardized digital lateral cephalograms were produced using regulated exposure conditions, with the Frankfort horizontal plane parallel to the floor and the teeth in centric occlusion. To reduce landmark identification errors, all radiographs were hand drawn on acetate sheets with a 0.5 mm lead pencil and uniform illumination.

The following cephalometric parameters were evaluated

FIGURES

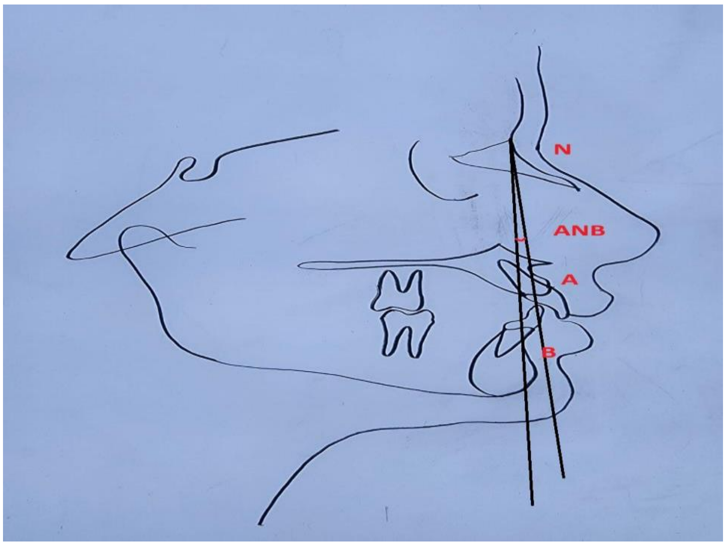


Figure 1. Assessment of Sagittal Skeletal Relationship (ANB Angle).

The ANB angle, formed by points Nasion (N), A, and B, was used to define the sagittal skeletal pattern. Only subjects with ANB values ranging from 0° to 4° were included to ensure a skeletal Class I relationship.

Angle)

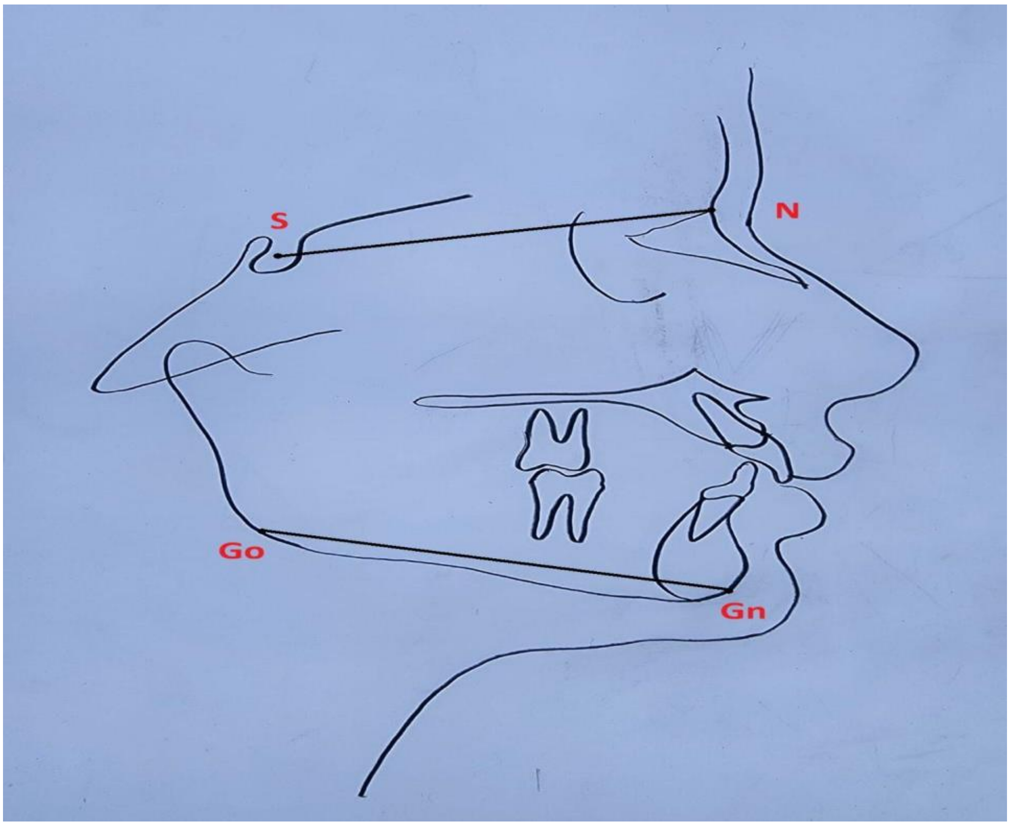


Figure 2. Evaluation of Vertical Skeletal Pattern (SN–GoGn Angle).

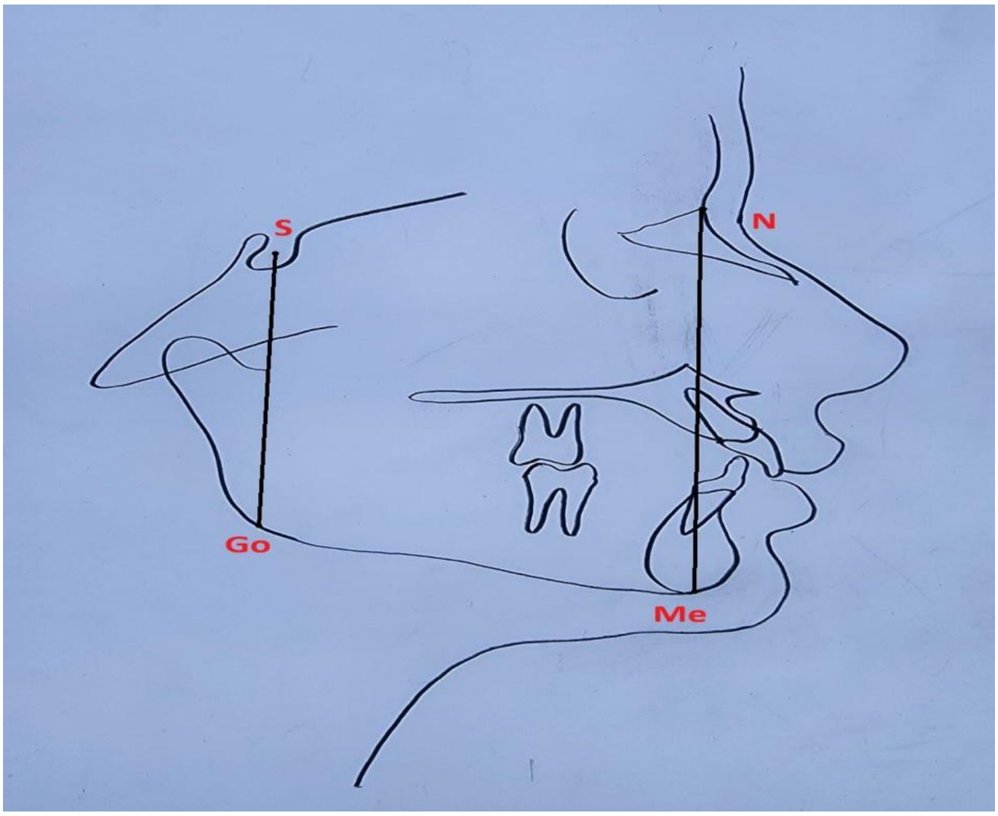


Figure 3. Measurement of Anterior and Posterior Facial Heights (Jarabak Ratio).

The vertical growth pattern was evaluated using the SN-GoGn angle, which is generated between the Sella-Nasion (SN) line representing the anterior cranial base and the Gonion-Gnathion (Go-Gn) mandibular plane. Increased values showed a vertical growth propensity, whereas lower values indicated a horizontal growth pattern.

Ratio)

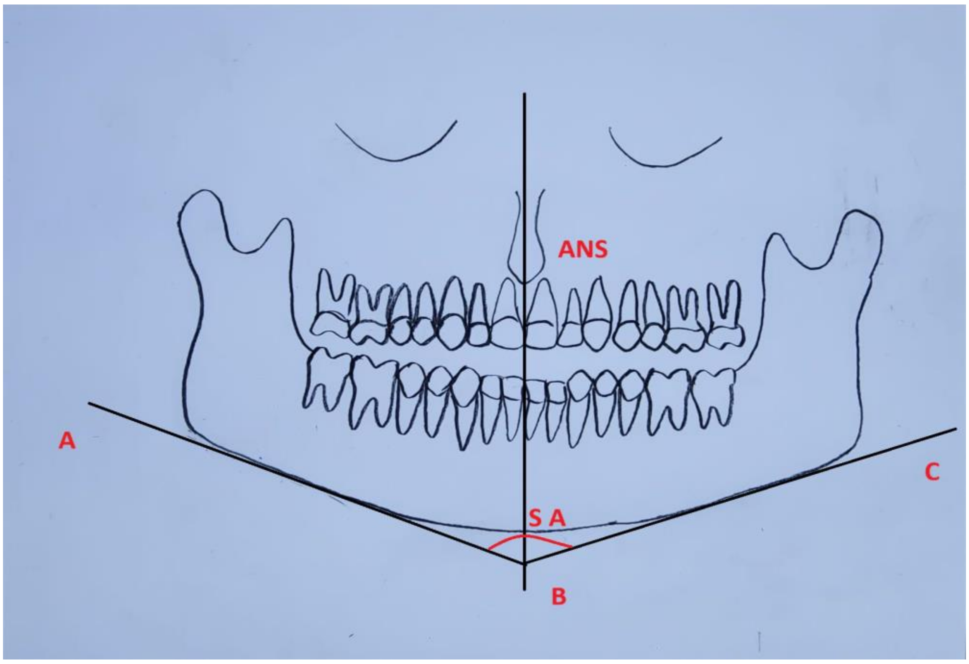


Figure 4. Construction of Symphyseal Angle (SA).

The Jarabak ratio (S-Go/N-Me × 100) was calculated by measuring both posterior and anterior face heights. This ratio was utilized to further categorize participants as horizontal, average, or vertical growth patterns.

The Symphyseal Angle (SA) was calculated on the frontal tracing by drawing tangential lines along the bilateral inferior mandibular boundaries that met at the menton area. The angle formed at the point of convergence was the symphyseal angle. The face midline crossing through the ANS serves as a reference for symmetry orientation.

RESULTS

In this study, skeletal Class I subjects' symphyseal angle and vertical skeletal parameters were compared. Based on their growth patterns, the samples were divided into three groups: average, horizontal, and vertical growers. The SN–GoGn angle, symphyseal angle, and Jarabak ratio were among the cephalometric parameters evaluated.

The SN–GoGn angle ranged from 24° to 34°, and the Jarabak ratio ranged from 60% to 75% in the group with average growth patterns. In comparison to the other groups, the symphyseal angle ranged from 133° to 155°, exhibiting moderate values.

The SN–GoGn angle displayed lower values between 10° and 26° in the horizontal growth pattern group, while the Jarabak ratio displayed higher values between 63% and 85%. The greatest measurements of the symphyseal angle were between 150° and 162°, representing the highest measurements among all groups.

Comparatively speaking, the Jarabak ratio was lower in the vertical growth pattern group, ranging from 57% to 62%. Higher mandibular plane inclination was indicated by the SN–GoGn angle, which varied between 34° and 38°. Of all the groups, the symphyseal angle had the lowest values, ranging from 131° to 142°.

When comparing the groups, the symphyseal angle was lowest in vertical growers, intermediate in average growers, and highest in horizontal growers. Symphyseal angle and Jarabak ratio were found to be positively correlated, while SN–GoGn angle and symphyseal angle were found to be negatively correlated. The differences between the groups were statistically significant ($p < 0.05$).

Statistical Analysis

The obtained data were tabulated and subjected to statistical analysis using descriptive and inferential statistics. Mean and standard deviation were calculated for Jarabak ratio, SN–GoGn angle, and symphyseal angle in each growth pattern group (Table 1).

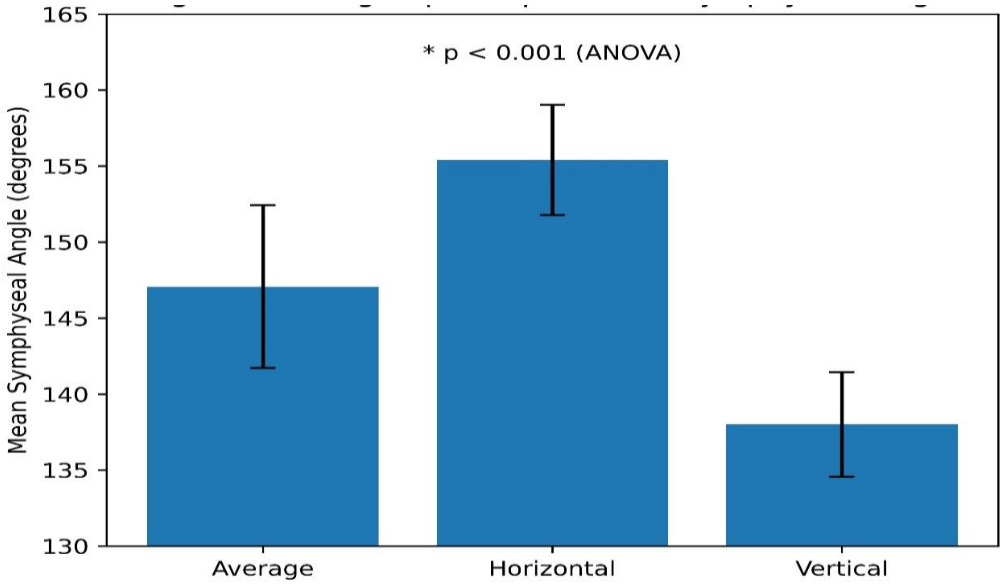
Table 1: Descriptive statistics (mean ± standard deviation) of Jarabak ratio, SN–GoGn angle and symphyseal angle in different vertical growth patterns.

Growth Pattern	n	Jarabak Ratio (Mean ± SD)	SN–GoGn (Mean ± SD)	Symphyseal Angle (Mean ± SD)
Average	15	65.80 ± 4.25	30.13 ± 2.72	147.07 ± 5.36
Horizontal	15	73.87 ± 6.05	20.13 ± 4.89	155.40 ± 3.62
Vertical	11	59.64 ± 1.50	36.09 ± 1.30	138.00 ± 3.44

Intergroup comparison of symphyseal angle among average, horizontal, and vertical growers was performed using one-way analysis of variance (ANOVA) (Table 2).

Table 2: Intergroup comparison of symphyseal angle among average, horizontal and vertical growth patterns demonstrated statistically significant differences (p < 0.001) (Table 2). This is illustrated in Graph 1.

Parameter	F value	p value	Significance
Symphyseal angle	52.06	< 0.001	Highly significant

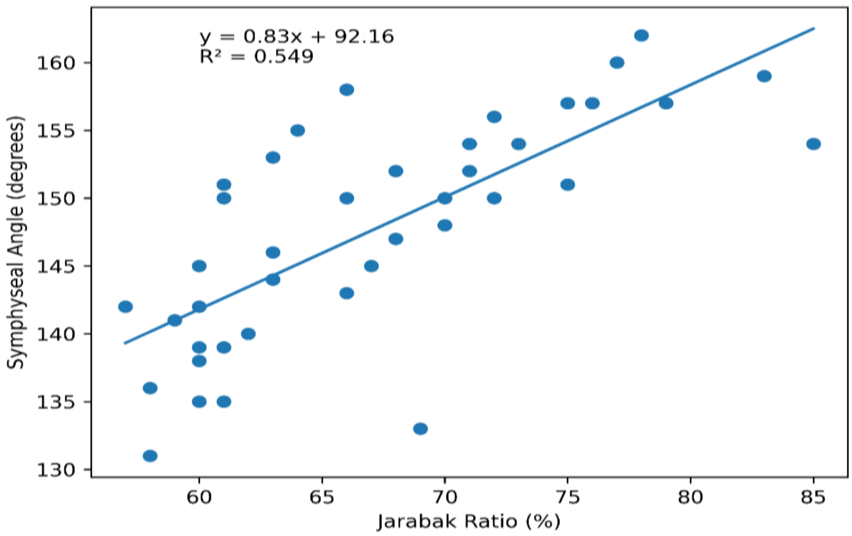


Graph 1: Intergroup comparison of mean symphyseal angle among average, horizontal, and vertical growth patterns (mean ± SD). One-way ANOVA showed a highly significant difference (*p < 0.001*).

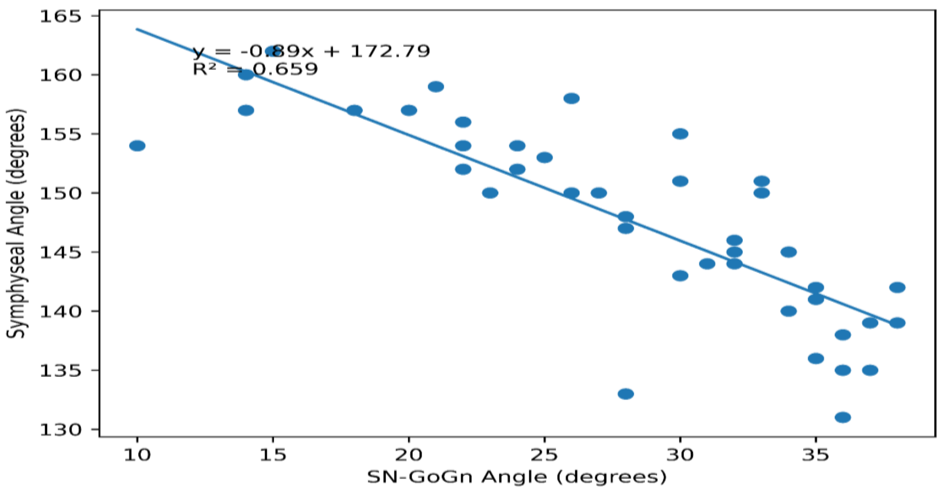
The relationship between symphyseal angle and vertical skeletal parameters was evaluated using Pearson's correlation coefficient (Table 3).

Variables Compared	Correlation Coefficient (r)	p value	Interpretation
Symphyseal angle vs Jarabak ratio	+0.741	< 0.001	Strong positive correlation
Symphyseal angle vs SN–GoGn angle	–0.812	< 0.001	Strong negative correlation

The results demonstrated a statistically significant difference in symphyseal angle among the growth pattern groups (p < 0.001) (Table 2). A strong positive correlation was observed between symphyseal angle and Jarabak ratio (r = 0.741), whereas a strong negative correlation was observed between symphyseal angle and SN–GoGn angle (r = −0.812) (Table 3, Graph 2 &3).



Graph 2: Linear regression analysis showing strong positive correlation between symphyseal angle and Jarabak ratio.



Graph 3: Linear regression analysis showing strong negative correlation between symphyseal angle and SN–GoGn angle.

DISCUSSION

Accurate assessment of vertical growth patterns is crucial in orthodontic diagnosis and treatment planning, particularly in skeletal Class I malocclusion. Even when sagittal jaw relationships are harmonious, vertical discrepancies can impact facial aesthetics, biomechanics, and treatment stability. Reliable indicators of true mandibular growth direction are essential, as conventional cephalometric parameters like SN–GoGn.

angle and Jarabak ratio may not adequately reflect mandibular remodeling.[12] Björk's research highlights that mandibular growth rotation involves structural changes; forward rotation leads to bone apposition and symphysis thickening, while backward rotation causes vertical elongation and narrowing.[13] The findings of the present study support this concept, as horizontal growers demonstrated the highest symphyseal angle while vertical growers showed the lowest values, indicating structural adaptation of the symphysis to growth rotation.

Jarabak claimed that the vertical growth tendency is determined by the ratio of posterior to anterior face heights. A larger Jarabak ratio indicates a horizontal growth pattern, whilst a smaller ratio suggests a vertical growth pattern.[14] The current study found a substantial positive link between symphyseal angle and Jarabak ratio, implying that increased posterior face height is related with a more upright and conspicuous symphysis. This suggests that symphyseal morphology is structurally related to vertical facial proportions.

The SN-GoGn angle denotes mandibular plane inclination and reflects the mandibular rotation pattern. An increased mandibular plane angle suggests rearward mandibular rotation and vertical facial expansion.[2] The current investigation found a significant negative connection between symphyseal angle and SN-GoGn angle. Björk's structural indicators of mandibular rotation were confirmed by the decrease in symphyseal angle as mandibular plane inclination increased.[13]

Skeletal Class I malocclusion was used for the current investigation to remove sagittal inconsistencies that could affect mandibular morphology. Dentoalveolar compensation can obscure actual vertical skeletal relationships in Class II and III malocclusions.[15] The large disparities between horizontal, average, and vertical growers suggest that symphyseal angulation is predominantly determined by vertical growth pattern rather than sagittal disparity.

The clinical relevance of symphyseal morphology is to determine the safe limits of orthodontic tooth movement. The alveolar housing limits incisor movement and prevents periodontal damage.[6] Horizontal growers have stronger incisor retraction due to thicker symphyseal bone, but vertical growers have limited alveolar support and a higher likelihood of dehiscence and recurrence. Therefore, evaluating symphyseal angle before treatment planning may assist clinicians in deciding extraction protocol and anchorage control.[16]

The statistically significant intergroup difference in symphyseal angle suggests that this metric can be used as a diagnostic tool. Morphological indications are often more reliable diagnostic tools than positional cephalometric measurements because they represent cumulative growth adaptation. Our study found robust relationships between symphyseal angle and mandibular growth rotation, similar to recognized cephalometric parameters, but from a structural perspective.[17]

LIMITATIONS OF THE STUDY

The study was cross-sectional and limited to skeletal Class I subjects, restricting the generalizability of results to other sagittal malocclusions. The use of two-dimensional cephalometric analysis may not fully capture three-dimensional symphyseal morphology.[18]

FUTURE SCOPE

Longitudinal studies with higher sample sizes are recommended to determine the predictive significance of symphyseal angle in growth evaluation. Three-dimensional imaging, such as CBCT, may offer a more accurate morphological assessment. Assessment in the skeletal Class II and Class III malocclusion groups may aid in the development of universal diagnostic standards.

CONCLUSION

The symphyseal angle varied significantly between vertical growth patterns, being highest in horizontal growers and lowest in vertical growers. A strong positive association was found with the Jarabak ratio, and a high negative correlation with the SN-GoGn angle. The data demonstrate that symphyseal morphology reflects mandibular growth rotation in line with Björk and Jarabak's growth principles. As a result, the symphyseal angle can be used as a credible supplementary cephalometric indication to assess vertical development pattern in skeletal Class I patients, thereby improving orthodontic diagnosis and treatment planning.

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