Unlocking Facial Harmony: Exploring the Sagittal Alignment of Maxilla and Mandible with the Anterior Cranial Base by Horizontal Appraisal Method

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ABSTRACT:

Background: Understanding the anteroposterior positioning between the maxilla and mandible is crucial for accurate orthodontic diagnosis. Various cephalometric analyses are utilized to evaluate sagittal skeletal imbalances, each possessing distinct strengths and limitations.

Objectives: This study aims to evaluate the sagittal relationship between the jaws and the anterior cranial base using the horizontal appraisal technique.

Materials and method: Ninety pre-treatment lateral cephalometric radiographs were analyzed and stratified into three skeletal classes (Class I, II, III) based on ANB angle, with 30 subjects in each group. A reference horizontal line was drawn at a 7° inclination from the Sella–Nasion (S–N) plane, and perpendicular vertical lines were extended from key cephalometric landmarks. The parameters assessed included ANB, Se–A, Se–B, Se–N, and Go–Me.

Results: The study found that ANB, Se–A, Se–B, and Se–N values differed significantly among the skeletal classes, while Go–Me also demonstrated considerable variation. However, parameters such as the saddle angle, Se–PNS, and ANS–PNS did not exhibit statistically significant differences.

Conclusion: The horizontal appraisal method proves to be a reliable approach for identifying anteroposterior skeletal imbalances and can be confidently implemented in daily orthodontic diagnostics.

KEY WORDS: Horizontal appraisal, Skeletal malocclusion, sagittal jaw discrepancy, cephalometry

INTRODUCTION

The evaluation of the sagittal relationship between the maxilla and mandible plays a pivotal role in orthodontic diagnosis. This relationship, particularly in the anteroposterior dimension, is often complex to analyse. Numerous cephalometric techniques have been developed over the decades to assess these discrepancies, each offering unique advantages and limitations. The foundational approach to assessing sagittal jaw relationships was introduced by **Downs** in 1948, who first defined points A and B. Later, in 1952, **Reidel** introduced the SNA and SNB angles and proposed using the ANB angle—the difference between SNA and SNB—to determine the skeletal relationship of the jaws. While the ANB angle is widely used and effective near normal ranges, it becomes less informative when values deviate significantly from the norm. This limitation arises partly because the nasion, a key landmark, tends to shift during growth, affecting the angle's reliability.In 1953, Steiner advocated for evaluating different craniofacial structures independently—skeletal, dental, and soft tissue components. Jacobson's Wits appraisal (1975) attempted to overcome the limitations of the ANB angle by projecting points A and B onto the occlusal plane instead of relying on cranial landmarks. However, since the occlusal plane is a dental reference, it is susceptible to alterations from tooth eruption and development.

To further enhance diagnostic accuracy, **Baik and Ververidou (2004)** introduced the Beta angle, which does not depend on cranial or dental landmarks. Subsequently, **Neela et al. (2009)** proposed the Yen angle, formed between the SM and MG lines—where M and G represent midpoints of the premaxilla and mandibular symphysis, respectively. Building on these advancements, **Nagar et al. (2014)**[2] proposed using an extracranial horizontal reference line that connects both denture bases. This approach avoids the limitations of the occlusal plane and simplifies the evaluation process. The present study applies this horizontal appraisal method to determine its reliability in evaluating sagittal discrepancies of the jaws.

AIM : To assess the anteroposterior positional relationship of the maxilla and mandible with respect to the anterior cranial base in individuals from the Solan population.

MATERIALS AND METHOD

This cross-sectional study utilized pre-treatment lateral cephalometric radiographs from patients receiving fixed orthodontic care at the Department of Orthodontics and Dentofacial Orthopaedics, Bhojia Dental College and Hospital, Baddi, District Solan, Himachal Pradesh. A total of 90 lateral cephalograms of individuals aged between 15 to 30 years were included in the analysis. Based on the ANB angle values, participants were evenly classified into three skeletal categories—Class I, Class II, and Class III—comprising 30 individuals in each group (see Table 1). A standardized manual tracing of all cephalograms was carried out by a single trained operator to avoid inter-observer variability. Anatomical landmarks (Table 2; Fig. 1) and reference planes (Table 3; Fig. 2a & 2b) were carefully identified. A true horizontal reference (HOR) line was constructed at an angle of 7° to the Sella-Nasion (S-N) line on the radiograph. From this line, true vertical lines (TVLs) were drawn perpendicular to the HOR line through specific cephalometric landmarks. Both linear (Table 4; Fig. 3) and angular (Table 5; Fig. 4) measurements were recorded and compared across the three skeletal classes to identify significant differences.

Inclusion criteria

- The sample should have skeletal Class I (ANB = 2±2º)[3]
- The sample should have skeletal Class II (ANB > 4º)[3]
- The sample should have skeletal Class III (ANB < 0)[3]
- High quality cephalometric radiographs.

Exclusion criteria

- Patients diagnosed with craniofacial syndromes or developmental anomalies
- Prior history of orthodontic intervention
- History of mandibular fractures or prior orthognathic surgery
- Patients with missing, supernumerary, or impacted teeth
- Patients with systemic illnesses affecting bone metabolism
- Patients with history of any systemic disease
- Patients on long-term medications known to influence bone growth

TABLE 1: GROUPING OF SAMPLES

N=90		
GROUP I	**GROUP II**	**GROUP III**
SKELETAL CLASS I n = 30	SKELETAL CLASS II n = 30	SKELETAL CLASS III n = 30

All lateral cephalograms were traced manually by the same operator and all the landmarks (Table:2, Figure:1)and planes(Table:3, Figure:2a, 2b) were identified and marked. True horizontal (HOR) line was drawn 7º on the film from the S-N Plane and True vertical lines (TVL) were drawn 90° to the true horizontal plane at various landmarks. Various linear (Table:4, Figure:3) and angular (Table:5, Figure:4) parameters were measured and compared for all the 3 groups.

TABLE 2:LANDMARKS USED IN THE STUDY[4]

S. No	Landmarks	Definitions
1	Sella (S)	The geometric midpoint of the sella turcica (pituitary fossa) located within the sphenoid bone.
2	Nasion (N)	The most anterior point at the junction of the frontal and nasal bones along the midline.
3	Point A	The deepest concavity found along the anterior profile of the maxilla between the nasal spine and alveolar ridge.
4	Point B	The most recessed point on the anterior contour of the mandibular alveolar process along the median sagittal plane.
5	Gonion (Go)	The inferoposterior point of the mandibular angle is formed by intersecting tangents to the posterior border of the ramus and the lower border of the mandible.
6	Menton (Me)	The lowest anatomical point on the mandibular symphysis located in the midline.

7	**Posterior nasal spine (PNS)**	The backmost projection on the hard palate, marking the posterior limit of the nasal cavity, situated at the intersection of the pterygopalatine fossa and nasal floor.
8	**Anterior nasal spine (ANS)**	It is the anterior tip of the sharp bony process of maxilla in the midline of the lower margin of anterior nasal opening

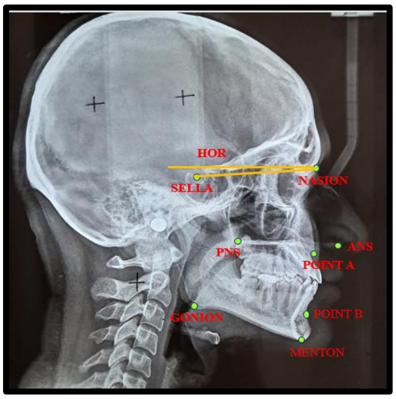

Fig 1: Landmarks

TABLE 3: PLANES[4]

S. No	PLANES	DEFINITIONS
1	**NA Plane**	This plane is drawn between nasion to point A.
2	**NB Plane**	This plane is drawn between nasion to and point B.
3	**Sella Nasion Plane (SN)**	This plane is drawn between Sella to nasion.
4	**Sella Articulare Plane**	This plane is drawn between sella to nasion.
5	**SE PNS Plane**	This plane is drawn between sella entrance.
6	**ANS -PNS Plane**	This plane is drawn between a line joining anterior nasal spine and posterior nasal spine.
7	**SE -N Plane**	This plane is drawn between Sella entrance to nasion.
8	**SE-B Plane**	This plane is drawn between Sella entrance to point B.
9	**Go -Me Plane**	This plane is drawn between a line joining gonion to menton.

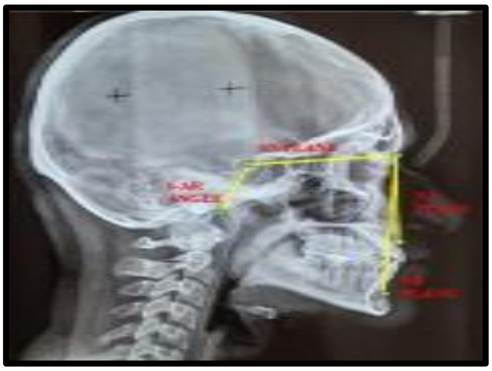

Fig 2a : Planes

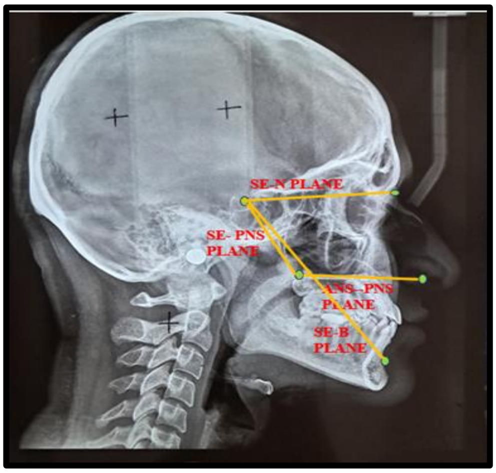

Fig 2b : Planes

TABLE 4: LINEAR PARAMETERS[4]

S. No	Parameter	Parameter
1	Se-PNS	Sella entrance to posterior nasal spine
2	ANS-PNS	Anterior nasal spine – Posterior nasal spine
3	Se-N	Sella entrance to nasion.
4	Se-A	Sella entrance to point A.
5	Se-B	Sella entrance to point A
6	Go-Me	Gonion – Menton

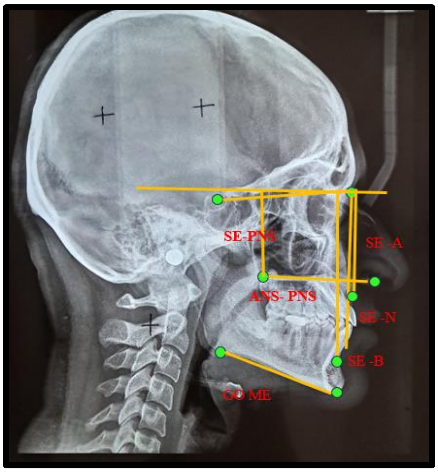

Fig 3 : Linear parameter

TABLE 5: ANGULAR PARAMETERS USED IN THE STUDY[4]

S. No	Parameters	Definations
1	**ANB angle**	It is the difference between SNA (sella-nasion to A point) and SNB (sella-nasion to B point)

2	**Saddle angle**	The angle between anterior and posterior cranial base

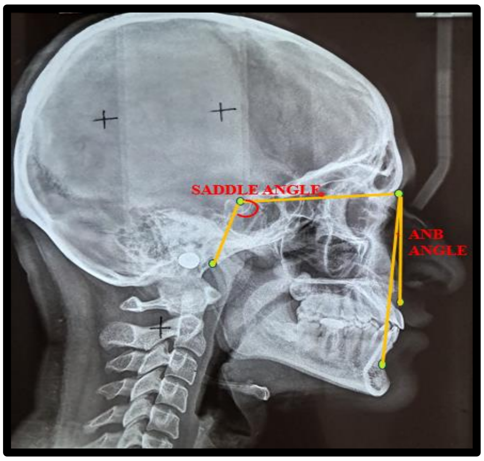

Fig 4 : Angular parameter

STATISTICAL ANALYSIS

The collected data was processed using SPSS software (version 24.0, IBM Corp., Chicago, IL, USA). Descriptive statistics, including mean and standard deviation, were computed for each variable. One-way analysis of variance (ANOVA) was applied to assess significant differences among the three skeletal malocclusion groups. A p-value of less than 0.05 was considered statistically significant.

RESULTS

TABLE 6: DESCRIPTIVE STATISTICS OF VARIOUS PARAMETERS IN DIFFERENT SKELETAL MALOCCLUSION GROUPS

Parameters	Group I (Class I) (Mean± S.D)	Group II (Class II) (Mean± S.D)	Group III (Class III) (Mean± S.D)
ANB	2.73 (±1.04)	2.36 (±1.06)	2.36 (±1.06)
Saddle A	124.83 (±3.44)	123.60 (±2.56)	123.60 (±2.56)
Se-A	44.16 (±2.50)	41.76 (±3.12)	41.76 (±3.12)
Se-B	76.40 (±4.05)	72.63 (±3.97)	72.33 (±4.20)
Se-N	54.26 (±2.37)	59.26 (±5.09)	59.26 (±5.90)
ANS-PNS	45.10 (±3.48)	42.23 (±4.08)	42.23 (±4.08)
Se-PNS	14.86 (±2.71)	15.00(±2.76)	15.00(±2.76)
Go-Me	54.16 (±4.67)	56.23 (±3.13)	56.23 (±3.13)

Table 6 shows descriptive statistics of various parameters. The ANB angle showed the highest mean in Class I (2.73 ±1.04), followed by Class II (2.36 ±1.06), wheras the lowest in Class III (-2.36 ±1.06). The saddle angle was greatest in Class I (124.83 ±3.44), with similar values observed in Classes II and III. Linear parameters such as Se–A and Se–B were also highest in Class I, indicating a more forward maxillary and mandibular skeletal pattern. The Se–N value, however, peaked in Class III. Go–Me was longest in Class II and III, suggesting greater mandibular length in those classes.

TABLE 7: COMPARISON OF PARAMETER ACROSS 3 GROUPS USING ONE-WAY ANALYSIS OF VARIANCE (ANOVA)

Parameter	Class I	Class II	Class III	F Value	P Value
ANB angle	2.73 ± 1.04	2.36 ±1.06	-2.36 ±1.06	231.377	**0.000***
Saddle angle	124.83 ±3.44	123.60 ±2.56	124.01 ±2.91	1.821	0.168
Se-A	44.16 ±2.15	41.76 ±3.12	42.56 ±3.11	6.691	**0.002***
Se-B	76.40 ±4.05	72.33 ±4.20	73.78 ±4.44	9.252	**0.000***
Se-N	54.26 ±3.27	59.26 ±5.09	59.26 ±5.90	9.312	**0.000***
ANS-PNS	45.10 ±3.48	42.23 ±4.08	42.23 ±4.08	5.419	0.006
Se-PNS	14.86 ±2.71	15.00± 2.76	15.00± 2.76	.024	0.977
Go-ME	54.16 ±4.67	56.23 ±3.13	56.23 ±3.13	3.084	**0.051**

Table 7 shows the Statistical testing revealing that ANB, Se–A, Se–B, and Se–N showed highly significant differences among the three skeletal classes ($p < 0.05$). The Go–Me measurement approached significance ($p = 0.051$). In contrast, the saddle angle and Se–PNS did not demonstrate statistically significant differences. ANS–PNS, though variable, did not reach statistical significance either. It was found that ANB ***(P=0.000*)***, SeA ***(p=0.002*)***, Se-B ***(p=0.00)***, Se-N ***(p=0.00)***, Go-ME***(p=0.051)*** approached statistical significance whereas Saddle Angle ***(p=0.168)***, Se-PNS ***(p=0.977)***, was found to be non-significant ***(p=0.08)***.

DISCUSSION

The accurate evaluation of sagittal discrepancies is a fundamental aspect of orthodontic diagnosis, essential for devising effective treatment strategies. This investigation sought to identify and compare the parameters—including two angular and six linear measurements—across different skeletal malocclusion classes (Class I, II, and III). The angular parameters included the ANB and saddle angles, while the linear assessments comprised Se–N, Se–ANS, Se–PNS, ANS–PNS, Se–A, Se–B, and Go–Me.

Upon comparing, ANB angle across the skeletal classes, was highest in Class I, slightly reduced in Class II, and negative in Class III—demonstrating statistical significance. This indicates a more protrusive maxillomandibular relationship in Class I cases relative to the others. These findings are consistent with those of **Nazir and Mushtaq (2020)**[5] and **Janson and Cattaneo (2007)**[6], who confirmed the utility of the ANB angle as a reliable metric for assessing sagittal jaw relationships. However, **Johnson et al. (2019)**[7] raised concerns about its applicability across ethnically diverse populations, suggesting variability in its diagnostic value.

The saddle angle, reflecting the cranial base flexure between the sphenoid and ethmoid bones, demonstrated the highest mean in Class I, a moderate value in Class III, and the lowest in Class II. Despite these differences, the variations were not statistically significant. This suggests that the saddle angle may not be a decisive parameter for classifying sagittal discrepancies. Similar conclusions were drawn by **Al-Rafidain et al. (2007)**[10]. In contrast, **Patel et al. (2016)**[9] highlighted its potential role in elucidating cranial base morphology and its relevance in differential diagnosis of skeletal patterns.

When analyzing the ANS–PNS dimension—an indicator of maxillary length—Class I subjects exhibited the greatest values, followed by Classes II and III, which showed nearly identical measurements. Although this trend suggests a more anteriorly positioned maxilla in Class I individuals, the observed differences did not reach statistical significance. **Al-Rafidain et al. (2007)**[10] reported comparable outcomes, while Patel et al. (2021) assessed no difference among skeletal patterns, supporting the non-significance of this metric.

The Se–PNS distance showed its highest measurement in Class III, followed by Class II, and lowest in Class I. Despite this gradient, the parameter failed to reach statistical significance, implying that this cranial base length remains relatively consistent irrespective of skeletal classification. These findings align with **Kim and Lee (2007)**[12], who reported minimal variation across skeletal groups. Conversely, **Thompson et al. (2020)**[13] observed statistically meaningful differences, suggesting potential sample-dependent outcomes.

Mandibular body length, represented by the Go–Me measurement, displayed a notable increase in Classes II and III when compared to Class I, indicating a potential trend toward greater mandibular development or downward rotation in more severe skeletal discrepancies. This observation aligns with the findings of **Hwang and Kim (2008)**[14], who similarly reported elevated Go–Me values in Class II and III groups. However, **Robinson et al. (2022)**[15] documented no statistically significant distinctions, highlighting ongoing debate regarding its clinical relevance.

Evaluation of Se–A distance, a linear indicator of maxillary positioning, revealed a maximum value in Class I, with Class II and III presenting comparatively lower and nearly identical values. These differences were statistically significant, emphasizing the diagnostic value of this parameter in sagittal assessment. **Singh and Gupta (2020)**[16] corroborated these findings, whereas **Lee and Lee (2018)**[17] reported less pronounced variations, possibly due to methodological differences or sample diversity.

The Se–B measurement, indicative of mandibular skeletal position, was highest in Class I and significantly reduced in Classes II and III. This difference suggests a retrusive mandibular base in the latter classes and was statistically significant. Similar patterns were identified in the study by **Lee and Yang (2019)**[18]. Conversely, **Smith and Jones (2018)**[19] found the distinctions between groups to be negligible, pointing to potential variability in measurement techniques or population-based anatomical differences.

Lastly, the Se–N measurement was notably higher in Classes II and III compared to Class I, with statistically significant differences among the three groups. This pattern implies a relative posterior displacement of cranial base structures in Class I or anterior displacement in the other classes. **Rodrigues and Carvalho (2021)**[20] supported this interpretation, reporting significant variability in Se–N across malocclusion types. However, **Singh and Gupta (2020)**[16] observed less marked differences, indicating possible inconsistencies arising from demographic or skeletal variation.

CONCLUSION

This study concludes that the horizontal appraisal proves to be a reliable and clinically efficient tool for evaluating sagittal skeletal relationships.

1. ANB angle effectively differentiates between Class I, II, and III skeletal patterns, with statistically significant variance.
2. Se–A, Se–B, Se–N, and Go–Me values also exhibit substantial differences across classes, underscoring their diagnostic utility.
3. Saddle angle, ANS–PNS, and Se–PNS did not display significant variation and may hold limited value for class differentiation in sagittal assessment.
4. Incorporating the horizontal appraisal technique into routine orthodontic diagnostics can enhance accuracy in skeletal classification and improve treatment planning outcomes.

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