Original Article

# Evaluating Diagnostic Validity of Various Sagittal Cephalometric Parameters (a Comparative Retrospective Study)

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## Abstract

**Objective:** The goal of this study was to determine the accuracy and reliability of numerous skeletal analyses for determining the sagittal skeletal pattern.

**Methods:** A total of 105 cephalometric x-rays were used. The Steiner's ANB angle, anteroposterior dysplasia indicator (APDI), and angle of convexity by Down's assessed the anteroposterior skeletal pattern. According to the diagnostic results of the majority of the criteria, the samples were divided into three classes: I, II, and III. The analyses' validity and reliability were assessed using Kappa statistics, positive predictive value, and sensitivity.

**Results:** There was a moderate agreement between the ANB angle and the final diagnosis (K= 0.593). The ANB angle demonstrated the highest sensitivity in class II and III groups (1.00).

**Conclusions:** The ANB angle and down's angle of convexity was the most accurate markers for class I and III groups, respectively, while the Down's angle of convexity and APDI were the most accurate indicators for class III group.


**Keywords:** *Cephalometry, Maxilla, Mandible, Malocclusion*.

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## Introduction

Orthodontic clinical examinations are completed using cephalometry, which is also used for diagnosis and individualized treatment plans[1]. Over the past 50 years, cephalometry has been continuously improving. It is also used to track patients' growth providing descriptive diagnosis, morphology, and clinical application. This can help predict the effects of conventional therapy and surgical treatment[2]. In addition, skeletal and dentoalveolar malocclusions can be compared by cephalometry. It shows the craniomaxillofacial complex's spatial relationships at a given time and permits comparisons over time[3,4].

Malocclusions can be caused by variations in normal craniofacial growth in the vertical, sagittal, or transverse planes[5]. For example, a convex or concave profile might come from a difference in sagittal development. This might be related to the face's hard or soft tissue changes. A convex profile with increased overjet and inadequate lips might result from a sagittal maxillary excess or mandibular deficit. A sagittal maxillary deficit or mandibular excess, on the other hand, might result in a prognathic profile and an anterior crossbite[6].

Various assessment methods assess anteroposterior relationships between mandibular and maxillary structures[7]. Different techniques have been suggested to determine the diagnosis of sagittal discrepancies. Downs[8] 1948 explained the AB plane angle as a plan to estimate the anteroposterior abnormality followed by the Downs angle of convexity. Riedel[9] 1952 presented the popular ANB point, which Steiner[10] generalized in 1953. Studies have shown that the ANB angle differs with the position of Nasion and the vertical pattern of growth[11,12]. Jacobson[12] proposed Wit's appraisal using the occlusal plane as the reference plane to solve this. Due to alterations in the occlusal plane[13]. Kim and Vietas[14] in 1978 created an anteroposterior dysplasia predicator, assuming that a specific cause does not cause discrepancies in the dentofacial complex. The diagnosis could be reliable with the combination of several different measurements. We have multiple criteria that have been and are still being implemented to deal with the shortcomings of current parameters for the effective diagnosis of sagittal discrepancies[6].

For treatment planning and treatment outcomes, reliable diagnostic criteria are required. Although several researchers have previously demonstrated the relationship between various skeletal analyses, only a few have examined different analyses' diagnostic validity and application. Therefore, this research aimed to determine the diagnostic agreement among various cephalometric techniques to measure anteroposterior parameters.

## Materials and methods

This comparative study was conducted on a total (of 105) standardized lateral cephalometric radiographs (male & female). The sample size was calculated using the coefficient of correlation (r) value = 0.704 reported by Ahmad et al.[15] with study power (β) of 80% and significance level (α) of 95%. Therefore, the minimum required sample size was 13 per group. These radiographs were collected from the digital files of the radiology department of the faculty of dentistry at Tishk International University. A good quality lateral cephalometric x-rays were included, and subjects with a history of previous orthodontic treatment were excluded. Therefore, to an extent, all the radiographs have different degrees of either dentoalveolar or skeletal malocclusion.

The lateral cephalographs chosen for this study were taken in natural head position (NHP) by Italian equipment's (new toms) GiANO, 1-10mA, for 10 sec from a fixed distance of 4 inches from the same cephalostat. The same investigator did all the tracing with a digital cephalometric analyzing tool (WebCeph).

The following sagittal measurements were traced by Webceph (Figure 1):

1- The angle of Convexity by Down[8]: The angle of convexity is formed by the intersection of N-A point to A-Pog point.

2- ANB angle by Steiner[10]: The intersection of lines connecting Nasion to point A and Nasion to point B creates the angle.

3- Anteroposterior dysplasia indicator (APDI) by Kim[14]: Is the mathematical sum of three angles Frankfort horizontal plane to the facial plane, A-B plane to the facial plane, and palatal plane to Frankfort horizontal plane.

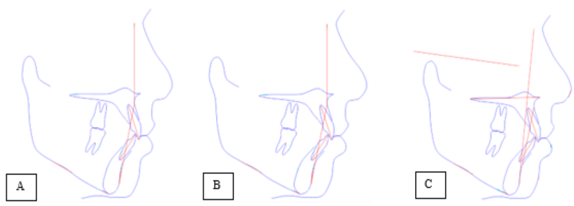


Figure 1: Cephalometric parameters traced by Webceph (A= ANB angle, B= Down's angle of convexity, C= APDI) .

Cephalometric norms for each one of the sagittal skeletal parameters were previously determined in the literature review used in this study[14,16] (Table 1). The subjects in this research were classified into three classes based on normal parameters: Class I, Class II, and Class III. Subjects with a similar sagittal skeletal pattern across all parameters were removed from the investigation. At least one parameter in the remaining 105 patients (42 men, 63 females) with ages ranging from (13-51) years old gave conflicting diagnoses of the sagittal skeletal relation. The final diagnosis was based on the most consistent results of the sagittal analyses. The sample size result per group (Class I, II, III) after the final diagnosis were as follows: n =59, 31, 15; respectively. Then when particular sagittal analyses in a subject agreed with the final diagnoses, it was labeled "properly diagnosed subjects."

Table 1: Cephalometric norms of sagittal parameters.

| Sagittal parameters | C I | C II | C III |
|---|---|---|---|
| Down's angle of convexity | -8.5 ° to 10 ° | > 10 ° | < -8.5 ° |
| ANB | 0 ° to 4 ° | >4 ° | <0 ° |
| APDI | 81.4 °±3.79 ° | <77.61 ° | >85.19 ° |

Ten lateral cephalograms were randomly selected and retraced by the same investigator at six-week intervals. Finally, the intraclass coefficient (ICC) was calculated to re-assure the reproducibility of all the parameters.

**Statistical analysis**

IBM's Statistical Package for Social Science (SPSS) application version 22 was utilized for data input and analysis. The mean and standard deviation were calculated as descriptive statistics. Pearson's correlation was used to analyze the anteroposterior skeletal parameters. The degree of agreement between the skeletal analyses and the final diagnosis obtained from the 'properly diagnosed subjects' was measured using Kappa statistics. Two-by-two tables were utilized to measure the validity in regard to sensitivity and positive predictive value (PPV).

## Results

The agreement between 1st and 2nd cephalometric tracing readings was excellent (Table 2). The samples in the research totaled 105 (42 men, mean age = 22.19 ± 5.03; 63 females, mean age = 23.38 ± 6.39). Table 3 shows the means and standard deviations for each parameter in all three sagittal malocclusions classes I, II, and III.

Table 2: Intraclass coefficient.

| Parameters | 1st tracing | 2nd tracing | ICC |
|---|---|---|---|
| ANB | 3.95 ± 1.8 | 3.96 ± 1.8 | 0.997* |
| Down's angle of convexity | 2.56 ± 5.1 | 2.18 ± 5.1 | 0.999* |
| APDI | 79.71 ± 4.0 | 78.33 ± 4.0 | 0.990* |

* ICC < 0.5 poor agreement, ICC between (0.5-0.75) moderate agreement, ICC between(0.75-0.9) Good agreement, ICC > 0.9 Excellent agreement.

Table 3: Mean value of sagittal cephalometric parameters.

| Parameters | Class I n= 59 Mean ± SD | Class II n= 31 Mean ± SD | Class III n= 15 Mean ± SD |
|---|---|---|---|
| Down's angle of convexity | 2.83±4.86 | 9.94±3.33 | -5.86±3.14 |
| ANB | 2.65±1.95 | 5.41±0.91 | -1.54±1.24 |
| APDI | 83.80±4.87 | 77.66±2.76 | 91.61±4.36 |

**Pearson's correlation**

Between ANB and Down's angle of convexity, a weak positive correlation was statistically significant (p-value < 0.05). The ANB angle analysis results appear to be related to Down's angle of convexity analysis results (Table 4).

There was a statistically significant (p-value < 0.05) weak negative correlation between APDI with ANB and Down's angle of convexity. The outcomes of the APDI angle analysis appear to be inversely connected to the outcomes of the ANB and Down's angle of convexity analysis (Table 4).

**Kappa statistics**

The agreement between diagnostic criteria of individual cephalometric studies was assessed using Kappa statistics. The final diagnosis obtained from the 'properly diagnosed cases' had a moderate agreement between ANB and down's angle of convexity, and it was statistically significant (p-value < 0.01). Furthermore, there was a statistically significant (p-value < 0.01) agreement between APDI and final diagnoses made from the 'properly diagnosed cases' (Table 5).

Table 4: Sagittal growth pattern is assessed using a correlation.

| | ANB | Down's angle of convexity | APDI |
|---|---|---|---|
| ANB<br>P-value | 1 | 0.243<br>0.012* | -0.221<br>0.024* |
| Down's angle of convexity<br>P-value | 0.243<br>0.012* | 1 | -0.199<br>0.042* |
| APDI<br>P-value | -0.221<br>0.024* | -0.199<br>0.042* | 1 |

* Pearson's correlation: weak correlation (±0.01 < r < ±0.5); moderate correlation (±0.5 < r < ± 0.8); strong correlation (±0.8 < r < ± 1). * P value < 0.05 level.

Table 5: Agreement of the diagnostic criteria for sagittal skeletal studies.

| Parameter | Class I n = 59 | Class II n = 31 | Class III n = 15 | Kappa n = 105 | P-value |
|---|---|---|---|---|---|
| ANB | 31 | 54 | 20 | 0.593 | 0.000* |
| Down's angle of convexity | 86 | 16 | 3 | 0.476 | 0.000* |
| APDI | 46 | 18 | 41 | 0.338 | 0.000* |

* n = 105, Kappa statistics. (Poor agreement = Less than 0.20, Fair agreement = 0.20 to 0.40, Moderate agreement = 0.40 to 0.60, Good agreement = 0.60 to 0.80, Very good agreement = 0.80 to 1.00). *. P value < 0.01.

**Positive predictive value and sensitivity**

The chance of having a class I relationship was 100%, a class II relationship was 57.4%, and a class III relationship was 75% in the ANB angle. The chance of identifying a class I relationship was 52.5%, a class II relationship was 100%, and a class III relationship was 100% in the ANB angle (Table 6).

The probability of those with class I relationship was 68.6%, class II relationship was 100%, and class III relationship was 100%. The chance to recognize the class I relationship was 100%, class II relationship was 51.6%, and class III relationship was 20% among those with Down's angle of convexity (Table 6).

The likelihood of having a class I relationship was 65.2%, a class II relationship was 83.3%, and a class III relationship was 36.6% among those with the APDI angle. Conversely, the chance of identifying a class I relationship was 50.8%, a class II relationship was 48.4%, and a class III relationship was 100% in this parameter (Table 6).

Table 6: Positive predictive value and sensitivity of sagittal skeletal pattern.

| parameter | Class I (n = 59) | | | Class II (n = 31) | | | Class III (n = 15) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Correctly diagnosed subject | PPV | sensitivity | Correctly diagnosed subject | PPV | sensitivity | Correctly diagnosed subject | PPV | sensitivity |
| ANB | 31 | 1.00 | 0.525 | 31 | 0.574 | 1.00 | 15 | 0.75 | 1.00 |
| Down's angle of convexity | 59 | 0.686 | 1.00 | 16 | 1.00 | 0.516 | 3 | 1.00 | 0.2 |
| APDI | 30 | 0.652 | 0.508 | 15 | 0.833 | 0.484 | 15 | 0.366 | 1.00 |

## Discussion

The cephalometric examination of the jaw relation in the anteroposterior plane has been given a lot of weight in orthodontics. Various analyses(8,10-12,17) have evaluated the anteroposterior jaw relation since Broadbent invented lateral cephalometry(18) in 1931. However, in borderline circumstances, multiple skeletal examinations may yield contradictory data, making a definitive identification of the anteroposterior skeletal pattern impossible. By analyzing the diagnostic accuracy of the most often used analyses, this study intended to condense the diagnosis procedure to minimal skeletal criteria.

There was a weak positive correlation between ANB and Down's angle of convexity in the current study, but it was statistically significant. Ishikawa et al.(19) found a strong correlation between the ANB and Down's angle of convexity, which might be ascribed to sample size disparities and the study's inclusion of only Class I patients. Ahmad et al.(15) also discovered a strong correlation between ANB and Down's angle of convexity; this difference in results might be because they only considered normal vertical development patterns, which could be a complicating factor.

A weak negative correlation between APDI with ANB and down's angle of convexity was discovered in this research. According to Trivedi et al.(20), the ANB angle has a moderately negative but significant relationship with the APDI. On the other hand, according to Ishikawa et al.(19), APDI and Down's angle of convexity and ANB angle have a moderately negative but significant relationship. This discrepancy in association with the current study's findings might be because they included class I cases and had a different sample size.

The interchangeability between the three parameters can be assessed by considering the basis for the geometric distortion effects in each parameter. Face, prognathism, age, and the developing rotation of the jaws regarding the cranial reference planes are all anteroposterior and vertical factors that influence ANB measurement. The anteroposterior location of the Nasion likewise influences it. The degree of rotation is related to the face pattern of the individual. Although face type does not affect the relationship between parameters, dolichofacial facial types have higher mean values than mesiofacial and brachyfacial facial types(21). This could be because the APDI composite has three separate values, making it less comparable to other parameters(19).

Another sagittal plane metric for examining jaw connections is convexity at point A. The location of the maxilla relative to the facial plane (N–Pog) impacts it. Accordingly, the Class III skeletal relationship can be detected in Class I malocclusion participants with a big chin. However, those with a less pronounced chin may have a Class II skeletal relationship(22). This might explain the lack of association between the ANB and Down's angle of convexity.

The amount of correlation does not mean that the supplied parameter can accurately diagnose the skeletal sagittal parameter. Consequently, the diagnostic agreement between numerous skeletal studies and the final diagnosis was examined using Kappa statistics. The angle of ANB and the final diagnosis had a moderate agreement. The Kappa statistic demonstrates the difference in diagnosis that can happen merely by chance(23). Therefore, the angle of ANB was discovered to be the most precise predictor for determining a patient's sagittal skeletal pattern.

An analysis must diagnose a parameter with consistency and precision. Therefore, the sensitivity of each parameter was determined to verify its diagnostic accuracy. The ANB angle had the most sensitivity in class II and III. In contrast, Down's angle of convexity had the utmost sensitivity in class I, and the APDI had the greatest sensitivity in class III. Therefore, Down's angle of convexity can be treated as a legitimate indication in examining the sagittal development pattern in a subject with Class I skeletal relation. Likewise, the angle of ANB may be utilized as a legitimate indication for class II subjects. In contrast, the ANB and APDI can be utilized to properly examine an individual's sagittal growth pattern for class III subjects.

Positive prediction values (PPV) were obtained for each group separately in the current investigation to confirm whether a particular parameter properly depicted the skeletal relation. In class I, the angle of ANB showed the highest PPV value followed by Down’s angle of convexity; in class II, the Down’s angle of convexity showed the highest PPV value followed by APDI, and in class III, the Down’s angle of convexity showed the greatest PPV value followed by ANB. We can assume from PPV results when evaluating the skeletal pattern in the sagittal plane in an individual that if certain parameters coincide, it is highly possible to be correct and may not require further investigation.

Consequently, the number of sagittal analyses for determining the skeletal disparity may be limited. However, these parameters revealed better diagnostic performance when contrasted to other parameters. This could lead to an accurate and time-saving diagnosis, boosting the treatment planning process' efficiency.

## Conclusions

The most precise indicators in measuring sagittal growth patterns in class I and III groups were the angle of ANB and down's angle of convexity. For class II group was down's angle of convexity and APDI.

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