Original Research Article

Evaluation of cephalometric analyses for assessing sagittal jaw relationship

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Abstract

Background: The sagittal discrepancies are most commonly encountered in day to day practice. Assessing these sagittal relationship is a challenging issue in orthodontics. **Aim:** To evaluate which of the cephalometric criteria is more reliable for clinicians and to determine the level of agreement between them. **Material and Methods:** A total of 100 lateral cephalograms were used for the study. The study sample was divided into 3 groups based on their skeletal relationship according to ANB angle, AFB angle and AB-Plane angle. **Results:** Statistically significant correlations were found among ten sagittal parameters with p-value <0.001. The correlation was very strong between FABA and AF-BF (r=0.931). Moreover, strong correlations existed between FABA angle and AXB (r=0.924), AXB and AF-BF(r=0.890), ANB angle and A-B plane angle (r=0.873). Lowest significant positive correlation was present between Wits and W-angle (r = 0.603) followed by Wits and APP-BPP (r= 0.652). **Conclusion:** The angular measurements with most homogenous distribution in the group were FABA angle. In linear measurements, most homogenously distributed was APP-BPP distance and measurements with least homogenous distribution was the Wits Appraisal. FABA was the most homogenously distributed parameter.
Keywords: sagittal jaw relationship, cephalometric analyses, ANB angle, AFB angle, FABA angle

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INTRODUCTION

Sagittal relationship between the upper and lower jaw represent the basic characteristic of human profile. It is one of the most important criteria assessed during the diagnosis of orthodontic anomalies.[1]In orthodontic diagnosis and treatment planning, cephalometric radiograph is considered to be a valuable tool. The sagittal discrepancies are most commonly encountered in day to day practice. Assessing these sagittal relationship is a challenging issue in orthodontics.[2] Cephalometrics has been adapted as an important clinical tool for assessment of jaw relationship in all the three planes-anteroposterior, transverse and vertical being an integral part of orthodontic treatment plan.[3] Over the last 50 years, many cephalometric parameters have been proposed to describe anteroposterior jaw relationships, and the conjunctive use of different parameters has been recommended for the assessment of the anteroposterior jaw discrepancy in individual patients.[4] Sagittal jaw relationships are difficult to evaluate because of rotations of the jaws during growth, vertical relationships between the jaws and the reference planes, difficulty in locating landmarks/points and a lack of validity of the various methods proposed for their evaluation. Any cephalometric analysis based on either angular or linear measurements has obvious shortcomings. Successful planning of treatment and treatment results depends on reliable diagnostic criteria. The aim of this study was to evaluate which of the cephalometric criteria

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is more reliable for clinicians and to determine the level of agreement between them.

MATERIAL AND METHODS

The study was carried out on the patients visiting the out-patient section of the Department of Orthodontics and Dentofacial Orthopaedics. A total of 100 lateral cephalograms were used for the study out of which 59 cephalograms belonged to male patients and 41 cephalograms belonged to female patients. The study sample was divided into 3 groups based on their skeletal relationship according to ANB angle, AFB angle and AB-Plane angle.
The subjects were selected based on the following criteria:

Inclusion criteria

- Varying degrees of skeletal and dentoalveolar malocclusions
- Age 13-30 years of age
- No previous orthodontic treatment

Exclusion criteria

- Subjects with congenital anomalies/syndromes
- Subjects with marked asymmetries
- Periodontal compromised patients.
- History of facial trauma.
- Previous history of orthodontic treatment.

Methodology

Sample Size Determination

For this study, the probability of type 1 error (α) was fixed at 5% and probability of type 2 errors (β) at 20%. Hence, the power of the study would be 80%. A prior sample size was calculated with G*Power (G*Power Ver. 3.0.10.) For a power of 80% with an f = 0.30 effect size, α=0.05 Type I and β= 0.20 Type II error rates, a sample size of at least 82 patients was determined. (α=Level of significance). The level of significance was set at 0.05. To increase the precision, we increased the sample size to 100.

Radiograph

The lateral cephalograms were taken from patients visiting the out-patient section of Department of Orthodontics and Dentofacial Orthopaedics. All cephalograms were taken with patients in standing position with teeth in centric occlusion and lips relaxed. All the cephalograms were taken using the same x-ray machine and a standard technique. The machine used was Newtom Giana NNT. No corrections for enlargement were made in the lateral cephalograms as all the cephalograms were taken using the same machine by the same operator. All the films were exposed with 64 KVp, 8 mA and an exposure time of 9 seconds.

Tracing of lateral cephalograms

All the cephalograms were traced on a standard acetate paper of 8”x10” size and 0.003” thickness by a standard technique using a soft 3H pencil using a view box. Tracings were done in a darkened room with no additional light. All the tracings were done by a single observer. Reproducibility was checked by retracing 20 radiographs randomly of the original sample after a gap of 3 weeks. The linear measurements were recorded with a measuring scale up to 0.5mm correction. The angular measurements were recorded with a protractor up to 0.5° corrections.

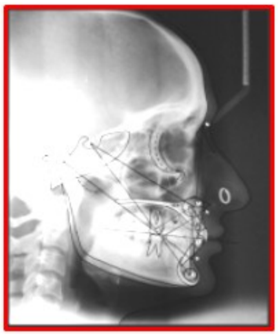

Figure 1: Measurements used in the study

Statistical analysis

The data of the study was subjected to descriptive tests, mean, standard deviation, range, maximum and minimum values and correlation coefficient for each measurement. The student’s t-test was applied to determine whether there were any differences between the measurements of male and female subjects. No statistically significant difference was found in any of the measurements. Correlation in different sagittal jaw parameters was studied to see for their interchangeability.

Measurement error and reliability

A single examiner performed all the registrations, landmark identification and measurements. Estimates of measurement error were calculated for all the cepahalometric parameters studied using double determination method i.e. the combined error of tracing and measurement was determined. Twenty cephalograms were randomly selected after a gap of three weeks and retraced by the same observer. Dahlberg’s formula was used to check the random errors as follows: ME = $\sum d^2$. Paired t-test was used to assess systematic errors. Thereby systematic differences and random errors could be determined.

Table 1: Parameters used in the study

S. N.	Parameter	Average value
1.	A-B plane angle	0 to -9 degrees
2.	ANB angle	0 to 4 degrees
3.	Wit's appraisal	Females (AO and BO coincide) Males (BO is 1mm ahead of AO)
4.	AXB angle	0 to 8 degrees
5.	AF-BF distance	3.87 ± 2.93 mm(males) 3.87 ± 2.63 mm(females)
6.	APP-BPP distance	4.8 ± 3.6 mm(males) 5.2 ± 2.9 mm(females)
7.	FABA angle	80.91 ± 2.53degreees
8.	BETA angle	27 to 35 degrees
9.	YEN angle	117 to 123 degrees
10.	W- angle	51 to 56 degrees

RESULTS

There were a total of 100 lateral cephalograms used for the study out of which 59 cephalograms were of male patients and 41 cephalograms were of female patients. The study sample was divided into 3 groups based on their skeletal relationship according to ANB angle, AFB angle and AB-Plane angle. First group consisted of lateral cephalograms of 35 subjects who were diagnosed to have a skeletal Class I sagittal jaw relationship. This group consisted of 18 male and 17 female subjects with a mean age of 19.57±4.00 years and an age range of 13 years to 29 years. The second group consisted of lateral cephalograms of 35 subjects who had a skeletal Class II sagittal jaw relationship. There were 20 male and 15 female subjects in this group. The mean age of this group was 20.48±3.58 years with an age range of 13 years to 30 years. Third group consisted of lateral cephalograms of 30 subjects with a skeletal Class III maxillo-mandibular relationship. There were 21 male and 09 female subjects in this group. The mean age of this group was 20.11±4.49 years with an age range of 13 years to 28 years. In order to analyze the data, within the entire sample, class strata of ANB angle, AB plane angle, Wits, AXB angle, FABA angle, AF-BF distance, APP-BPP distance, beta angle, YEN angle and W-angle angle were defined. The assessments of sagittal jaw relationship by ten methods of analyses showed the differences in distribution of cases in each skeletal class as shown in table 1. Angles like AXB, AB plane, ANB, YEN and BETA showed the greatest percentage in Class I among all ten indicators of the sagittal skeletal intermaxillary relationship while as Wits showed showed the greatest percentage in Class III.

Table 1: Comparison of assessments of sagittal jaw relationship by ten method of analysis

Method of Analysis	No. of cases in each skeletal category		
	Class I	Class II	Class III
A-B plane angle	46	28	26
ANB angle	45	32	23
Wit's appraisal	17	35	48
AXB angle	55	27	18
AF-BF distance	35	40	25
APP-BPP distance	39	40	21
FABA angle	28	27	45
BETA angle	45	20	35
YEN angle	41	24	35
W- angle	38	17	45

Statistically significant correlations were found among ten sagittal parameters with p-value <0.001. The correlation was very strong between FABA and AF-BF (r=0.931). Moreover, strong correlations existed between FABA angle and AXB (r=0.924), AXB and AF-BF(r=0.890), ANB angle and A-B plane angle (r=0.873). Lowest significant positive correlation was present between Wits and W-angle (r = 0.603) followed by Wits and APP-BPP (r=0.652) as shown in Table 2. When angular and linear parameters were compared, high significant positive correlation was found between FABA angle and AF-BF distance (r=0.931).

Table 2: Descriptive statistics of pooled group

	Minimum	Maximum	Mean	SD	CV (%)
A-B plane angle	-16	6	-4.16	6.03	-145.0
ANB angle	-7	11	2.06	4.18	202.7
Wit's appraisal	-11	12	-0.42	4.80	-1142.9
AXB angle	-5	14	4.19	4.77	113.8
AF-BF distance	-6	19	4.74	5.32	112.2
APP-BPP distance	-6	21	5.75	5.86	101.9
FABA angle	65	102	83.18	4.28	5.1
BETA angle	19	52	33.19	7.67	23.1
YEN angle	105	135	121.80	6.72	5.5
W- angle	40	70	56.28	4.73	8.4

The angular measurements with most homogenous distribution in the group were FABA angle (CV=5.1) followed by YEN, W-angle, and BETA angle, AF-BF, AXB and ANB (Table 2). In linear measurements, most homogenously distributed was APP-BPP distance (CV=101.9) and measurements with least homogenous distribution was the Wits Appraisal (CV=-1142.9). FABA had the lowest coefficient of variability among the cephalometric parameters measured (CV=5.1), indicating that it was the most homogenously distributed parameter (Table 2).

Table 3: correlation matrix for A-B PLANE, ANB, WITS, AXB, AFBF, APP-BPP, FABA, BETA, YEN AND W-ANGLES

		AB PLANE	ANB	WIT'S	AXB	AFBF	APP BPP	FABA	BETA	YEN	W
AB PLANE	r										
	P-value										
ANB	r	0.873									
	P-value	***									
WITS	r	0.785	0.518								
	P-value	***	***								
AXB	r	0.857	0.886	0.792							
	P-value	***	***	***							
AFBF	r	0.801	0.837	0.688	0.890						
	P-value	***	***	***	***						
APP BPP	r	0.803	0.882	0.753	0.887	0.847					
	P-value	***	***	***	***	***					
FABA	r	0.876	0.893	0.753	0.924	0.931	0.867				
	P-value	***	***	***	***	***	***				
BETA	r	0.829	0.826	0.817	0.833	0.756	0.751	0.833			
	P-value	***	***	***	***	***	***	***			
YEN	r	0.842	0.848	0.683	0.846	0.800	0.819	0.825	0.766		
	P-value	***	***	***	***	***	***	***	***		
W	r	0.803	0.726	0.603	0.754	0.696	0.652	0.740	0.746	0.874	
	P-value	***	***	***	***	***	***	***	***	***	

***Statistically Significant Correlation(P-value<0.05)

(r- correlation coefficient; p- value)

DISCUSSION

Cephalometric radiograph is a valuable tool in orthodontic diagnosis and treatment planning. More recent studies have shown that there is no perfect and absolutely reliable parameter for assessing sagittal skeletal relationship. In this respect, there is a clinical recommendation that several indicators should be used to determine more realistic skeletal class diagnosis. Pearson's correlation of different sagittal parameters used to assess maxillo-mandibular relationship. All the parameters had highly significant relation to each other in the present study. The high correlation coefficients among ten sagittal parameters denote that these parameters are closely related to each other and may be used interchangeably. In the present study, FABA had highest correlation with AF-BF (r= 0.931) closely followed by FABA and AXB (r=0.924). Similar findings have been reported by other authors.[5,6] These correlations can be explained by the fact that all of them utilize the same reference plane. FABA is more accurate in assessing sagittal jaw relationship when compared with other angular and linear measurements. In the present study, angular methods used for assessing jaw relationship such as FABA, AXB, YEN, Beta and W-angle and linear measurements such as APP-BPP and AF-BF distance could demonstrate superiority for assessing antero-posterior jaw relationship over other methods such as Wits, AB plane, and ANB which showed more variability. Almost similar findings have been reported by other studies.[7]Kannan S *et al.*,[7] evaluated the reliability of sagittal methods utilizing FABA, AXD, MM Bisector, Beta angle, JYD angle, AB plane angle, ANB angle, AXB angle, AF- BF and APP-BPP. They suggested that angular methods such as FABA, AXD, Beta angle and linear measurements such as APP-BPP, MM Bisector could demonstrate superiority for assessing anteroposterior jaw relationship over the methods such as AXB, AB plane, ANB angle and AF-BF. Similarly, Bhardwaj P *et al.*[8] compared and correlated Beta angle with other angular and linear measurements for assessment of sagittal skeletal discrepancy. They also found that correlation between Beta angle and ANB, AFB, AO-BO, AF-BF and APP-BPP demonstrate that with the increase of Beta angle antero-posteriorly skeletal dysplasia decreases significantly.There is statistically significant correlation between Beta, YEN and W-angle ($p<0.001$) in our study which is also supported by studies of Sachdeva K *et al.*,[9] Ververeidou B *et al.*,[10] Neela[11] and Bhad.[12] Sachdeva K *et al.*[9] compared ANB angle, Wits appraisal, Beta angle, Yen angle and W angle, to assess the most reliable measurement. They concluded that Beta angle, Yen angle and W angle are significant angles to assess the sagittal jaw relationship between maxilla and mandible which is consistent with our study. Palla A *et al.*[13] showed in their study that the coefficient of variation values of Beta angle are significantly consistent than ANB angle and Wits appraisal suggesting that Beta angle is reliable. The correlation and regression analysis for the total sample suggests a highly significant relation between Beta angle and ANB angle and, between Beta angle and Wits appraisal. Since, it has been found that Beta angle could assess sagittal discrepancies in the population; it can be used in orthodontic diagnosis and treatment planning in addition to the traditionally used measurements. Less significant correlation was found between Wits and ANB ($r= 0.518$) followed by Wits and W-angle ($r= 0.603$), APP-BPP and Wits ($r= 0.652$) W-angle and AFBF in the present study. Statistically significant but low correlation has been found between ANB and Wits ($r=0.518$) in our study. Kirchner and William[14] also found statistically significant correlation (p-value <0.05) between the Wits and ANB angle but stated that 'in clinical terms one parameter is only very slightly dependent on the other'. Tamara Boskovi[15] revealed a statistically significant and high correlation between ANB angle Wits values. Peterson and Bishara[16] concluded that despite the significant correlation between ANB angle and Wits ($p<0.001$), its magnitude was not high ($r=0.598$). These results were in agreement with Zhou *et al.* and Wellens.[17,18] Rotberg's[19] study also suggested there was no strong and predictable correlation between ANB angle and Wits. Among linear measurements, the parameter with most homogenous distribution was APP-BPP (CV=101.9) and the least homogenous was Wits (CV=-1142.9) in our study. Coefficient of variability is highest for Wits followed by AB-plane angle and ANB angle indicating that Wits was the least reliable parameter and is in agreement with other studies.[5,20] The greatest coefficient of variability may be attributed, in part to difficulties or inaccuracies in identifying the functional occlusal plane and/or variation in it. Moore *et al.*[21] and Ishikawa *et al.*[4] also stated that Wits appraisal although not affected by landmarks or jaw rotations; it still has the problem of correctly identifying the functional occlusal plane, which can sometimes be impossible, especially in mixed dentition. Furthermore, changes of the Wits measurement throughout orthodontic treatment might also reflect changes in the functional occlusal plane rather than pure sagittal changes of the jaws. Yang and Suhr[22] evaluated the coefficient of variability in Class I skeletal group to indicate the anteroposterior relationship which is similar to current study in which coefficient of variation has been evaluated for three skeletal groups. Significantly lower values were found by the above authors for ANB angle and Wits than our study. Wits appraisal was found to be skewed in the class III direction in our study. This has also been reported by Nanda, who compared A to B measurement on palatal plane with the ANB angle, the AO-BO or Wits appraisal, and nasion perpendicular in 50 randomly selected persons to determine the difference in diagnostic measures of the sagittal maxilla-mandibular relation. In those persons determined to be class I and class II by the A to B measurement on palatal plane, the Wits appraisal was found to be biased in favour of class III relationships. Similarly, diagnosis from other methods in this study did not reveal a specific bias, and all these measures accurately described class III skeletal relations. While a reasonably high agreement in the distribution of cases among skeletal classes was found between A-B plane and angle ANB which is consistent with the present study. After wits, ANB and A-B plane angles showed maximum variability in the present study which is in agreement with the findings of Kannan *et al.*.[7] This related to the previous findings that change in the relative position of nasion affects ANB. When angular and linear parameters were compared, high significant positive correlation was found between FABA angle and AF-BF distance ($r = 0.931$, $p<0.05$). In the present study FABA was found to be least variable indicating that it was the most homogeneously distributed parameter (CV=5.1). FABA is more accurate in assessing sagittal jaw relationship when compared with other angular and linear measurements. 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SD[22] has also shown that FABA has most homogenous distribution and there is high correlation between FABA and AFB (r=0.98) which is in agreement with our study. In contrast, some studies[20] have shown that YEN angle is highly reliable (CV=1.81) and most homogenously distributed angular parameter to assess AP sagittal discrepancy while APDI was shown to have the most homogenous distribution.

CONCLUSION

The angular measurements with most homogenous distribution in the group were FABA angle. In linear measurements, most homogenously distributed was APP-BPP distance and measurements with least homogenous distribution was the Wits Appraisal. FABA was the most homogenously distributed parameter.

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