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Assessment Of Various Anteroposterior Relationships – A Cross-Sectional Retrospective Study

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Abstract

Objectives: The objective of this study is to measure and compare different parameters of anteroposterior jaw dysplasia and to check the reliability amongst them for the population. Material and Methods: 180 individuals pre-treatment lateral cephalogram of the various skeletal patterns were taken from the archives of the dental college records. The lateral cephalogram of these individuals was traced manually and nine parameters were measured. Pearson correlation analysis was used to assess the correlation between these cephalometric variables and the Intra-class correlation coefficient was used to determine intra-observer reliability.

Result: The highest positive correlation was found between AXB and AF-BF (r = 0.89) and the highest negative correlation was found between ANB and AB plane angle (r = -0.94). Pi analysis showed a high correlation with the other cephalometric variables.

Conclusion: Pi analysis is the most reliable parameter and Wit's appraisal was the most erratic parameter. However, linear and angular measurements are altered by growth changes in facial height and jaw inclination. Therefore, the use of these parameters in conjunction with each other should be emphasized for orthodontic diagnosis and treatment planning.

Keywords: Sagittal/Anteroposterior discrepancies; Cephalometrics; Pi analysis; NHP

Introduction

A cephalometric radiograph is a valuable tool in orthodontic diagnosis and treatment planning.[1] The skeletal discrepancy is described in three planes - transverse, sagittal, and vertical. Among them, sagittal discrepancies are most commonly encountered in daily practice. There are various angular and linear parameters proposed by different authors to diagnose these discrepancies.

To determine these basal relationships, Downs introduced the A-B plane angle[2]; Riedel recommended SNA, SNB, and ANB angles.[3] Steiner and Reidel said the SN plane could be used as a reference line.[4,5] However, it has been seen that the ANB angle is affected by several environmental factors and thus tempering the diagnosis.[6] To eliminate the influence of the anatomic variations in nasion on the sagittal relationship of the jaws. Jacobson presented the Wits appraisal which was less affected by variations in craniofacial physiognomy.[7] But, the occlusal plane was not easily reproducible, especially in mixed dentition cases or in the steep curve of spee.[8] Sherman et al reported that the value of the Wits appraisal does not necessarily remain stable throughout the growth period.[9]Freeman eliminated the Nasion point by using AXB angle so that the degree of divergence of the face does not affect the readings.[10]

Yang in 1995 introduced FABA using Frankfort Horizontal Plane as a reference.[11] However, it has been reported that the Frankfort plane is not a true horizontal which makes it difficult to accurately diagnose. The cranial references or dental occlusion as reference planes had their limitations. Measurement independent of them would be a desirable adjunct in determining the apical base relationship. Baik and Ververidou introduced a Beta angle that does not depend on any cranial landmarks or dental occlusion to assess the sagittal jaw relations.[8] It uses three skeletal landmarks – point A, point B, and the apparent axis of the condyle. However, it becomes difficult to locate the points and the condyle is not visible in a radiograph. Neela et al in 2009 introduced the YEN angle.[12] The morphological landmarks – the midpoint of sella turcica (S), the midpoint of the premaxilla (M), and center of the largest circle that is tangent to the internal inferior, anterior, and posterior surface of mandibular symphysis (G). These points are not influenced by local remodeling secondary to dental movements, unlike points A and B.

Kumar et al in 2012 developed another anteroposterior jaw relationship as Pi analysis.[13] In this a true horizontal plane, i.e. a line perpendicular to true vertical in NHP was obtained. So, the purpose of this study is to measure and compare different parameters of anteroposterior jaw dysplasia and which is the most reliable amongst them for the Indian population.

Aim

To determine the most suitable sagittal jaw discrepancy parameters of an Indian population.

Objective

To measure and compare AB Plane, AF-BF, ANB, AXB, Beta angle, FABA, Pianalysis, Wits appraisal & Yen angle and to determine the most reliable parameters.

Materials And Methods

Pre-treatment 180 lateral cephalograms (56 males and 124 females) having various skeletal patterns (Class I, Class II, and Class III) with the age ranging between 15-25 years selected from the archives of the dental college. A retrospective cross-sectional study design was used with a purposive sampling technique. The inclusion criteria were patients with both skeletal / or dentoalveolar malocclusion who have not undergone orthodontic treatment and patients with no missing teeth except third molars. The exclusion criteria were medically compromised patients with open bite, multiple impactions, skeletal asymmetries, and craniofacial anomalies and with poor-quality radiographs.

The lateral cephalograms were recorded by the same radiographic technician (to minimize the error) with the same equipment (Sirona Orthophos XGS, Germany) in standardized conditions the natural head posture (NHP) using cephalostat. A tube voltage of 73 kV, a tube current of 15 mA, and an exposure time of approximately 9.4 sec were used.

Analysis Of Radiographs

The lateral cephalograms were traced manually on a 0.003" matte acetate tracing sheet with a 0.3 mm lead pencil using a tracing board by a single examiner. The following cephalometric landmarks, planes, angles were identified and anteroposterior cephalometric parameters were measured and compared.

- Cephalometric lines or planes:
    1. Sella-nasion plane (SN): the line connecting from Sella to Nasion,
    2. Frankfort horizontal plane (FH): the line connecting from Porion to Orbitale,
    3. AB Plane: the line connecting from point A to B,
    4. NP Plane: the line connecting from Nasion to Pogonion,
    5. CB Plane: the line connecting the geometric center of the condyle to point B,
    6. A-CB: the line from point A perpendicular to CB line,
    7. AX: the line perpendicular from point A to X,

Volume 5, Issue 2; March-April 2022; Page No 585-594

8. XB: the line joining from point B to X,
9. TVL: a true vertical line is drawn from the radiographic image of a true vertical metallic scale.
10. THL: true horizontal line is perpendicular to the true vertical line passing through Nasion (N).

- Cephalometric angular and linear measurements: (Fig 1.)

1. AB plane angle: angle between NPog plane and AB plane.
2. SNA (Steiner): the angle formed by points S, N, and A.
3. SNB (Steiner): the angle formed by points S, N, and B.
4. ANB (Steiner): the difference between SNA and SNB.
5. Beta angle: angle between A-CB to AB line.
6. AXB angle: angle between AX to XB line.
7. FABA angle: angle between FH plane and AB plane.
8. YEN angle: angle between Sella (S), (M) Midpoint of the anterior maxilla & (G) center at the bottom of the symphysis and measured at M point.
9. Pi Angle: angle between G, G', and M.
10. AO-BO: the distance in mm between perpendiculars drawn from point A and B onto the functional occlusal plane.
11. AF-BF: the distance in mm between perpendiculars drawn from points A and B onto the FH plane.

Pi linear: the distance in mm between perpendiculars drawn from G and M onto the true horizontal line. As shown in Figure 1.

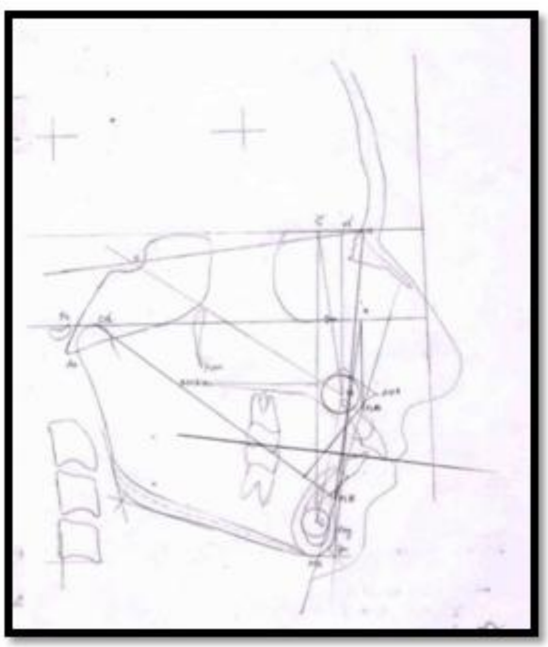

Figure 1: Tracing on Lateral Cephalogram

Statistical Analysis

Data was collected and fed in Microsoft Excel (Version 2010) and was analyzed using Statistical Package for Social Sciences software for Windows (SPSS, Version 17). Descriptive statistics were calculated for age and different cephalometric

Volume 5, Issue 2; March-April 2022; Page No 585-594

variables. The student 't' test was used for comparing the age of male and female subjects. Pearson correlation analysis was performed to assess the association between the different cephalometric variables. A two-tailed (α=2) P value less than 0.05 ($p<0.05$) was considered statistically significant.

Twenty radiographs were selected randomly and their tracings and measurements were repeated two weeks after the first measurements by the same examiner to determine the errors associated with the radiographic measurements. Intra-observer reliability of measurements was assessed by intra-class coefficient correlation analysis.

Results

Table 1shows the descriptive statistics of the 180 subjects comprising of 56 males and 124 females. The age range of males and females was 15-25 years. The mean age of males was 19.45 ± 2.75 and females was 20.01 ± 2.90 respectively. The student 't' test showed an insignificant ($p > 0.05$) difference between the age of males and female subjects.

Table 2 shows the distribution of study samples in different skeletal classes as assessed by different cephalometric variables. Wit's appraisal showed the highest frequency (63.9%) in the skeletal class II category and the lowest frequency (6.1%) in the skeletal class I category. In skeletal class, I category AB plane angle showed the highest frequency (61.7%) and Wit's appraisal showed the least frequency (6.1%). In the skeletal class II category, Wit's appraisal showed the highest frequency (63.9%) and AB plane angle showed the least frequency (16.1 %). In the skeletal class III category, FABA showed the highest frequency (47.8%) and AF-BF linear measurements showed the least frequency (16.1%).

Table 3 shows descriptive statisticsandTable 4shows the correlation matrix of these variables as. The mean AB plane angle was - 4.52 ± 5.03^o with a range of - 15^o to 7^o. AB Plane angle showed a strong negative correlation ($r = -0.94$, $p < 0.001$) with ANB angle and a positive correlation with Wit’s appraisal ($r = 0.23$, $P < 0.01$). The mean ANB angle was – 2.96 ± 3.76^o with a range of - 7^0 to 11^o. ANB angle showed a strong negative correlation ($r = -0.94$, $p < 0.001$) with AB plane angle and a strong positive correlation with Pi angular and linear ($r = 0.80$, $p < 0.001$). The mean Wit's appraisal was – 1.04 ± 4.99 mm with a range of -10 mm to 22 mm. Wit's appraisal showed a negative correlation ($r = -0.27$, $p < 0.001$) with Pi linear and a positive correlation with AB plane angle ($r = 0.24$, $p < 0.01$). The mean Beta angle was – 33.48 ± 6.68^o with a range of - 19^0 to 52^o. Beta angle showed a strong negative correlation ($r = -0.82$, $p < 0.001$) with AF-BF distance and a strong positive correlation with YEN angle ($r = 0.86$, $p < 0.001$).

The mean FABA angle was – 82.52 ± 7.19^o with a range of - 69^0 to 100^o. FABA angle showed a strong negative correlation ($r = -0.93$, $p < 0.001$) with AXB angle and a strong positive correlation with YEN angle ($r = 0.87$, $p < 0.001$). The mean AF-BF was 3.99 ± 5.66 mmwith a range of -8 mm to 18 mm. AF-BF showed a strong negative correlation ($r = -0.91$, $p < 0.001$) with FABA and a strong positive correlation with AXB angle ($r = 0.89$, $p < 0.001$). The mean AXB plane angle was 3.9 ± 4.77^o with a range of - 10^0 to 13^o. AXB angle showed a strong negative correlation ($r = -0.93$, $p < 0.001$) with FABA and a strong positive correlation with AF-BF ($r = 0.89$, $p < 0.001$). The mean YEN angle was 120.8 ± 8.25^o with a range of 100 to 140^o. YEN angle showed a strong negative correlation ($r = -0.87$, $p < 0.001$) with AF-BF and a strong positive correlation with FABA ($r = 0.87$, $p < 0.001$). The mean Pi angular was 3.22 ± 6.25 with a range of -10^o to 20^o. Pi angular showed a strong negative correlation ($r = -0.77$, $p < 0.001$) with AB plane angle and a strong positive correlation with ANB angle ($r = 0.80$, $p < 0.001$). The mean Pi linear was 3.00 ± 6.25 with a range of -11to 19 mm. Pi linear showed a strong negative correlation ($r = -0.77$, $p < 0.001$) with AB plane angle and a strong positive correlation with ANB angle ($r = 0.80$, $p < 0.001$).

The highest positive correlation was found between AXB and AF-BF ($r = 0.89$, $p < 0.001$) and least positive correlation was found between ANB and Beta ($r = 0.04$, $p > 0.05$). The highest negative correlation was found between ANB and AB plane angle ($r = -0.94$, $p < 0.001$) and least negative correlation was found between Beta angle and Pi analysis ($r = -0.01$, $p > 0.05$).

The most homogenous distribution was seen with YEN angle (6.8%) and the least homogenous distribution was seen with Wit's appraisal (480.4%).

Table 5shows intraobserver reliability of different cephalometric variables. A high positive correlation coefficient ($r = 0.762$ to 0.967) was found between

Volume 5, Issue 2; March-April 2022; Page No 585-594

the first and the second radiographic measurements of the nine cephalometric variables which were statistically significant ($p < 0.001$). The highest correlation coefficient was found for YEN angle ($r = 0.967$, $p < 0.001$) and the least was found for FABA ($r = 0.762$, $p < 0.001$) for intra-observer reliability.

Discussion

Proper diagnosis and treatment planning plays important role in a successful orthodontic treatment.[14] The introduction of lateral cephalometry to the field has made it easier to establish the relationships between facial, skeletal, dental, and soft tissue structures. One of the important and common applications of lateral cephalograms is determining the anteroposterior position of jaws relative to each other and cranial base.

A retrospective cross-sectional study design was selected and no additional radiographic exposure was done to the patient. Digital cephalograms were recorded by the same technician under NHP.[15]

The ANB angle and the Wits appraisal are the most commonly used parameters used to evaluate sagittal discrepancies. The validity of these parameters has been investigated by many studies.[8,16]Jacobsonshowed that the ANB angle does not provide an adequate assessment of jaw relationships because rotational growth of the jaws and the anteroposterior position of nasion influence the ANB angle.[7] Hussels and Nanda noted two additional factors affecting the ANB angle- the vertical lengths from nasion to point B and from point A to point B.[17] Roth and Chang showed that the Wit's appraisal is affected by the vertical dimensions of the jaws and the occlusal plane inclination.[18,19] To eliminate these distorting effects, methods of geometric correction of both parameters have been introduced[9,10,17,18] but these involve complicated procedures. Use of these two parameters in conjunction with other parameters describing jaw relationships is usually advisable.

The result of the study showed the difference in the distribution of the sample in different skeletal classes assessed by nine cephalometric variables. Wit's appraisal showed the highest frequency (63.9%) in the skeletal Class II category and lowest (6.1%) in the skeletal ClassI category. Jacobson and Bhardwaj also reported the highest frequency of Wit's appraisal in skeletal Class II groups.[7, 20]

In the present study, the greatest coefficient of variability was observed with Wit's appraisal (480.4%) this is due to difficulty in accurately determining the occlusal plane because of the overlapping of the right and left landmarks. The lowest coefficient of variability was seen with the YEN angle (6.8%) as it depends upon stable points S, M, and G and is not influenced by growth changes. However, growth rotations of the jaw masked true basal dysplasia.

The highest positive correlation was found between AXB and AF-BF ($r = 0.89$) and the least negative correlation was found between Beta angle and Pi analysis. The correlation of the Beta angle with other parameters was strongest with YEN angle ($r = 0.86$) and least with AF-BF ($r = -0.82$). The correlation of FABA with AXB angle showed a negative correlation ($r = -0.93$) and the correlation of AXB with AF-BF showed a strong positive correlation ($r = 0.89$) which was similar to the study done by **E**rum et al.[1] YEN angle showed a strong positive correlation with FABA ($r = 0.87$) and Pi analysis showed a positive correlation with ANB angle ($r = 0.80$) which was dissimilar to the study done by Mittal et al.[21]

Pi analysis showed maximum correlation with the other cephalometric variables followed by YEN angle as it is based on a true horizontal and vertical plane that passes through Nasion. Pi angle is minimally affected by vertical movement of Nasion and is not affected by its forward movement. Kumar et al. found that the effect of jaw rotation has an insignificant effect on Pi analysis.[13] Mittal et al. observed that Pi analysis is 100% sensitive and credible analysis in discriminating between skeletal class I, II, and III category.[21] Neela et al and Sachdeva et al reported that the YEN angle was not influenced by growth changes as it is based on geometrically constructed points that are better representative of the underlying skeletal pattern.[12,22]

In recent studies 2021 the variation as well as correlation existing between these 3 parameters, so that a more presumable and least variable parameter to obtained. A Total of 70 lateral cephalograms of skeletal class II patients were selected based on Down's facial angle and tracing was carried out manually to measure ANB, Beta, and YEN angles.

Volume 5, Issue 2; March-April 2022; Page No 585-594

Statistical analysis was carried out to assess the coefficient of variation and the Pearson coefficient. It was concluded that the YEN angle is highly predictable and a homogeneously distributed angular parameter used to assess sagittal discrepancy in class II patients compared to ANB and Beta angles.[23,24]

Conclusion

Despite varying strength of association, a statistically significant correlation was found among nine methods for assessing the sagittal jaw relationship. The pi analysis is the most reliable parameter followed by the YEN angle and Wit's appraisal was the most erratic parameter. However, linear and angular measurements are altered by growth changes in facial height and jaw inclination. Therefore, the use of these parameters in conjunction with each other should be emphasized for orthodontic diagnosis and treatment planning. Future studies should be conducted on normal occlusion subjects to eliminate the effect of jaw sizes and rotations on these cephalometric variables.

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Table 1: Descriptive statistics of the study sample

Sex	N	Min	Max	Mean	SD	P-value
Males	56	15	25	19.45	2.75	0.223
Females	124	15	25	20.01	2.90	
Total	180	15	25	19.83	2.86	

N = Sample Size, Min = Minimum Value, Max = Maximum Value,
SD = Standard Deviation, P = Level of Significance

Table 2: Distribution of study sample in different skeletal classes as assessed by different cephalometric variables

Cephalometric Variables	Number of subjects in each skeletal class		
	Class I	**Class II**	**Class III**

Volume 5, Issue 2; March-April 2022; Page No 585-594

	N	%	N	%	N	%
A-B plane (degrees)	111	61.7	29	16.1	40	22.2
ANB (degrees)	63	35.0	74	41.1	43	23.9
Wit's appraisal (mms)	11	6.1	115	63.9	54	30.0
Beta (degrees)	88	48.9	32	17.8	60	33.3
FABA (degrees)	17	9.4	77	42.8	86	47.8
AF-BF (mms)	100	55.6	51	28.3	29	16.1
AXB (degrees)	16	8.9	96	53.3	68	37.8
YEN (degrees)	64	35.6	64	35.6	52	28.8
Pi ANGULAR (degrees)	46	25.6	71	39.4	63	35.0
Pi LINEAR (mms)	43	23.9	70	38.9	67	37.2

% = Frequency distribution

Table 3: Descriptive statistics of different cephalometric variables

Cephalometric Variables	Min	Max	Median	Mean	SD	SE	CV (%)
AB plane (degrees)	-15	7	-6	-4.52	5.03	0.38	-111.5
ANB (degrees)	-7	11	4	2.96	3.76	0.28	126.9
Wit's appraisal (mms)	-10	22	2	1.04	4.99	0.37	480.4

Beta (degrees)	19	52	33	33.48	6.68	0.50	19.9
FABA (degrees)	69	100	81	82.52	7.19	0.54	8.7
AF-BF (mms)	-8	18	5	3.99	5.66	0.42	142.0
AXB (degrees)	-10	13	5	3.90	4.77	0.36	122.3
YEN (degrees)	100	140	120	120.80	8.25	0.62	6.8
Pi ANGULAR (degrees)	-10	20	4	3.22	6.25	0.47	194.3
Pi LINEAR (mms)	-11	19	4	3.00	6.25	0.47	208.5

SE = Standard Error, CV % = Coefficient of Variation Percentage

Table 4: Correlation matrix between cephalometric variables

Variables	**r/P value**	**AB plane angle**	**ANB**	**Wit's Appraisal**	**Beta**	**FABA**	**AF-BF**	**AXB**	**YEN**	**Pi angular**	**Pi linear**
AB plane Angle	r	1.00									
	P	1.00									
ANB	r	-0.94[c]	1.00								
	P	$p \leq 0.001$	1.00								
Wits appraisal	r	.24[b]	-0.35[b]	1.00							
	P	.01	$p \leq 0.001$	1.00							
Beta	r	-0.04[ns]	.04[ns]	.09[ns]	1.00						
	P	.57	.576	.238	1.00						
FABA	r	-0.19[a]	.18[a]	.06[ns]	.83[c]	1.00					
	P	.011	.016	.418	$p \leq 0.001$	1.00					
AF-BF	r	.10[ns]	-0.10[ns]	-0.06[ns]	-0.82[c]	-0.91[c]	1.00				
	P	.172	.188	.441	$p \leq 0.001$	$p \leq 0.001$	1.00				

r =

AXB	r	.15^{a}	-0.13^{ns}	-0.06^{ns}	-0.81^{c}	-0.93^{c}	.89^{c}	1.00			
	P	.047	.088	.409	p≤0.001	p≤0.001	p≤0.001	1.00			
YEN	r	-0.11^{ns}	.11^{ns}	.09^{ns}	.86^{c}	.87^{c}	-0.87^{c}	-0.82^{c}	1.00		
	P	.129	.136	.218	p≤0.001	p≤0.001	p≤0.001	p≤0.001	1.00		
Pi Angular	r	-0.77^{c}	.80^{c}	-0.26^{c}	-0.01^{ns}	.15^{a}	-0.06^{ns}	-0.11^{ns}	.09^{ns}	1.00	
	P	p≤0.001	p≤0.001	p≤0.001	.855	.038	.438	.130	.241	1.00	
Pi linear	r	-0.77^{c}	.80^{c}	-0.27^{c}	-0.01^{ns}	.15^{a}	-0.06^{ns}	-.11^{ns}	.09^{ns}	.99^{c}	1.00
	P	p≤0.001	p≤0.001	p≤0.001	.851	.044	.427	.149	.239	p≤0.001	1.00

correlation coefficient, ^{ns} $p>0.05$, ^{a} $p<0.05$ level, ^{b} $p<0.01$, ^{c} $p<0.001$

Table 5: Intraobserver reliability of different cephalometric variables

Cephalometric variables	ICC r value	p-value
AB plane (degrees)	0.796***	< 0.001
ANB (degrees)	0.841***	< 0.001
Wits appraisal (mms)	0.937***	≤0.001
Beta (degrees)	0.854***	< 0.001
FABA (degrees)	0.762***	< 0.001
AF-BF (mms)	0.915***	≤0.001
AXB (degrees)	0.873***	< 0.001
YEN (degrees)	0.967***	≤0.001
Pi ANGULAR (degrees)	0.821***	< 0.001
Pi LINEAR (mms)	0.775***	< 0.001

ICC = Intra-class Correlation Coefficient**,** *** $p<0.001$

Volume 5, Issue 2; March-April 2022; Page No 585-594