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ORIGINAL ARTICLE

A Comparison of Cephalometric Analyses for Assessing Sagittal Jaw Relationship

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ABSTRACT

Objective: To compare the seven methods of cephalometric analysis for assessing sagittal jaw relationship and to determine the level of agreement between them.

Study Design: Cross-sectional, analytical study.

Place and Duration of Study: Dental Section, the Aga Khan University Hospital, Karachi, from January to December 2004.

Methodology: Seven methods, describing anteroposterior jaw relationships (A-B plane, ANB, Wits, AXB, AF-BF, FABA and Beta angle) were measured on the lateral cephalographs of 85 patients. Correlation analysis, using Cramer's V-test, was performed to determine the possible agreement between the pair of analyses.

Results: The mean age of the sample, comprising 35 males and 50 females was 15 years and 3 months. Statistically significant relationships were found among seven sagittal parameters with p-value <0.001. Very strong correlation was found between AXB and AF-BF distance (r=0.924); and weak correlation between ANB and Beta angle (r=0.377). Wits appraisal showed the greatest coefficient of variability.

Conclusion: Despite varying strengths of association, statistically significant correlations were found among seven methods for assessing sagittal jaw relationship. FABA and A-B plane may be used to predict the skeletal class in addition to the established ANB angle.

Key words: *Cephalometry. Sagittal jaw relationship. Malocclusion.*

INTRODUCTION

In orthodontic diagnosis and treatment planning, great importance has been attached to evaluate the sagittal apical base relationship. This may be affected clinically by an overall profile view of the patient,[1] but a more accurate impression may be given by palpation of the anterior surfaces of the basal part of the jaws with teeth in occlusion.[2] Angle in 1907 provided one of the first assessments of jaw relationship based on the permanent molar relationship; however, this is representative of the anteroposterior relationship of dentition only. With Broadbent's introduction of the cephalometer in 1931,[3] a new era began in orthodontics.

The first step in evaluating anteroposterior jaw relationship cephalometrically was Down's description of points A and B.[4] A few years later, Riedel used angle ANB,[5,6] which later on became an important part of many analyses e.g. Steiner's analysis and is the most commonly used measurement since that time.[7,8] However, it has been claimed that the ANB angle is affected by a number of misleading factors and may give false results;[9-13] therefore, number of new measurements have been developed.[14-19]

Jacobson in 1975 eliminated the cranial reference points and used occlusal plane as a reference base.[14-15] It has come to be known as the Wits appraisal. However, Sherman *et al.* reported that value of the Wits appraisal does not necessarily remain stable throughout the growth period.[20]

Freeman in 1981 aimed to eliminate point N, so that the degree of divergence of the face does not affect the readings.[16] Chang in 1987 reported an alternative measurement based on linear assessment of the distance between perpendiculars from points A and B onto the Frankfurt horizontal plane.[17] Sang in 1995 described another measurement based on Frankfurt horizontal plane as a reference.[18] However, it has been reported that Frankfurt plane is not a true horizontal and in spite of the known uncertainty of accurately locating porion in cephalometrics, the Frankfurt plane has proved adequate for facial typing.[4]

Baik and Ververidou in 2004 reported a new measurement 'the beta angle' that does not depend on any cranial landmarks or dental occlusion for assessing sagittal jaw relationship.[19]

All of these parameters, which diagnose the sagittal discrepancy, have the standard mean values. One needs little familiarity with the statistical method to understand that failure to demonstrate significant differences between means does not eliminate a

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variable as a potential factor in the production of anomaly. The method presented by Wylie permits the localization of dysplasia in one or more of five different areas, which is more valuable than derivation of a net score.[21] This also indicates the necessity of looking elsewhere for existing dysplasia.

Successful planning of treatment and treatment results depends on reliable diagnostic criteria. The aim of this study was to evaluate which of the aforementioned criteria was more reliable for clinicians and to determine the level of agreement between them.

METHODOLOGY

This cross-sectional study included orthodontic patients who visited the Department of Orthodontics, Section of Dentistry at the Aga Khan University Hospital, Karachi, from January to December 2004. Pre-treatment lateral cephalometric radiographs were obtained from the orthodontic record files and were used for this study.

The sampling technique was purposive sampling. Inclusion criteria were subjects exhibiting varying degrees of skeletal and/or dentoalveolar malocclusions, having never received orthodontic treatment, and with complete diagnostic records including availability of good quality cephalometric radiographs. Exclusion criteria were subjects with congenital anomalies/ syndromes and marked asymmetries.

After detailed scrutiny of all patients in the specified study duration, records of 85 patients (50 females, 35 males aged between 6 years and 11 months to 39 years and 6 months) fulfilling the above-mentioned criteria were selected for the study.

The pre-treatment cephalographs were traced manually onto a cellulose acetate sheet by the primary author using fluorescent tracing screens to provide illumination. All cephalographs were obtained in the standing posture with the same radiographic equipment.

The definitions of cephalometric landmarks, lines or planes and measurements used in the study are as follows.

Cephalometric landmarks included the following; N (Nasion): being the most anterior point at the fronto-nasal suture; S (Sella turcica): geometric center of the pituitary fossa; A (subspinale): deepest point at the concavity below anterior nasal spine; B (supramentale): deepest point at the concavity below infradentale; Or (orbitale): the lowest point on the lower margin of the bony orbit; Po (porion): the superior most point on the external auditary canal; C: The geometric center of the condyle; Pog (pogonion): the most anterior point on the bony chin and X: the point at Frankfurt horizontal perpendicular from point A.

Cephalometric lines or planes used were: Sella-nasion plane (SN), Frankfurt horizontal plane (FH), the line connecting from Po to Or, AB as line connecting from A to B, NP as line connecting from N to Pog, CB as line connecting C to B, A-CB as line from point A perpendicular to CB line, AX being perpendicular line from A to X and XB as the line joining from X to B.

Cephalometric measurements used were of two categories. Angular measurements included NP-AB (downs): angle between NP plane and AB plane; SNA (Steiner): angle formed by point S, N and A; SNB (Steiner): angle formed by point S, N and B; ANB (Steiner): the difference between SNA and SNB; beta angle: the angle between A-CB to AB line; AXB: angle between AX to XB line and FABA: angle between Frankfurt plane and AB plane.

Linear measurements included AO-BO as the distance in mm between perpendiculars drawn from point A and B onto the functional occlusal plane. AF-BF was the distance in mm between perpendiculars drawn from point A and B onto the Frankfurt horizontal.

To determine the errors associated with radiographic measurements, 10 radiographs were selected at random. Their tracings and measurements were repeated 4 weeks after the first measurement and Wilcoxon sign rank test was used for intra-examiner reliability.

Descriptive statistics were calculated to find the means and standard deviations. Correlation analysis was performed using Cramer's V-test to determine the possible agreement between the pair of analyses. P-value less than or equal to 0.05 was considered statistically significant. All statistical analyses were performed on SPSS 13.0 software for Windows (SPSS, Chicago, Ill).

RESULTS

Out of the 85 patients in the study, 50 (58.8%) were females. The mean age was 15 years and 3 months. The assessments of sagittal jaw relationship, by seven methods of analyses, showed the differences in distribution of cases in each skeletal class as shown in Table I. Wits appraisal showed the highest frequency of cases in class III malocclusion.

The coefficients of variability of the seven parameters used in the assessment of sagittal jaw relationship are quite different from each other (Table II). According to these coefficients, the measurement with the most homogenous distribution was FABA, followed by beta angle; least homogenous was the Wits appraisal.

Statistically significant correlations were found among seven sagittal parameters (Table III) with p-value < 0.001. The correlation was very strong between AXB and AF-BF distance (r=0.924). Moreover, strong correlations existed between A-B plane and ANB angle (r=0.749), AXB and FABA (r=0.724), AF-BF distance and FABA (r=0.657), whereas, there was a weak correlation between ANB and beta angle (r=0.377), while the remaining showed moderate level of correlations.

No statistically significant differences (p > 0.05 Table IV) were found between the first and second radiographic measurements showing intra-examiner reliability.

Table I: Comparison of assessments of sagittal jaw relationship by seven method of analysis.

Method of analysis	Number of cases in each skeletal category		
	Skeletal I n (%)	Skeletal II n (%)	Skeletal III n (%)
A-B plane	44 (51.8)	32 (37.6)	9 (10.6)
Angle ANB	36 (42.4)	41 (48.2)	8 (9.4)
Wits appraisal	44 (51.8)	19 (22.4)	22 (25.9)
AXB angle	29 (34.1)	49 (57.6)	7 (8.2)
AF-BF distance	23 (27.1)	55 (64.7)	7 (8.2)
FABA	28 (32.9)	42 (49.4)	15 (17.6)
Beta angle	44 (51.8)	29 (34.1)	12 (14.1)

Table II: The range of measurements of pooled group.

Method of analysis	minimum	maximum	mean	Standard deviation	Coefficient of variation (%)
A-B plane	-17	17	-6.82	5.81	-85.2
ANB	-10	9	3.89	3.15	81.0
Wits	-15	9	-0.512	4.24	-828.1
AXB	-12	15	6.47	3.92	60.6
AF-BF	-12	16	7.018	4.44	63.3
FABA	61	112	78.69	7.04	8.9
Beta	15	53	29.28	7.06	24.1

Table III: Correlation matrix for A-B plane, ANB, Wits, AXB, AF-BF, FABA and Beta (r- correlation coefficient; p-value).

		A-B Plane	ANB	Wits	AXB	AF-BF	FABA	Beta
A-B Plane								
ANB	r	0.749						
	p	***						
Wits	r	0.486	0.423					
	p	***	***					
AXB	r	0.562	0.454	0.468				
	p	***	***	***				
AF-BF	r	0.544	0.468	0.438	0.924			
	p	***	***	***	***			
FABA	r	0.596	0.534	0.437	0.724	0.657		
	p	***	***	***	***	***		
Beta	r	0.420	0.377	0.506	0.496	0.491	0.456	
	p	***	***	***	***	***	***	

**** p-value <0.001*

Table IV: Intra-examiner reliability.

	A-B plane (2nd)– A-B plane (1st)	ANB (2nd)– ANB (1st)	Wits (2nd)– Wits (1st)	AXB (2nd)– AXB (1st)	AF-BF (2nd)– AF-BF (1st)	FABA (2nd)– FABA (1st)	Beta (2nd)– AXB (1st)
P-value	0.317	1.000	0.317	0.180	0.157	0.317	0.31

(1st) First reading, (2nd) Second reading

DISCUSSION

Dentofacial balance and harmony and growth and development have been studied by many investigators in four dimensions: namely height, depth, breath, and time, using lateral cephalometric radiographs.[22] Most orthodontic problems occur in the anteroposterior and vertical plane, so the lateral cephalographs provide the most useful information.

Many studies have been published on ANB angle and Wits appraisal methods,[9,12,16,17,23] and some on the A-B plane, AXB angle and AF-BF distance,[24-27] but none exist on the FABA and the beta angle. The results of this study showed (Table I) the differences in distribution of cases in each skeletal class by the seven methods of analysis for assessing sagittal jaw relationship. Wits appraisal was found to be skewed in the class III direction. 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 maxillomandibular relation.[11] 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.

The results of this study showed the difference in coefficients of variability of the seven parameters used. However, the greatest coefficient of variability of the Wits appraisal (-828.1) may be attributed in part due to difficulties or inaccuracies in identifying the occlusal plane and/or variations in it.[9,14,17] In addition, it can be easily affected by the vertical dimensions of the jaws and the occlusal plane inclination.[23] Oktay also showed more variation in the Wits appraisal than the ANB, AF-BF distance and Anteroposterior Dysplasia Indicator (APDI) measurements, similar to the present results.[26] However, in Chang's sample, as opposed to the present, are the coefficient of variability of the ANB angle was higher than that of the AF-BF measurements.[17]

The measurement with the most homogenous distribution in this study was FABA. Similar result was found by Yang.[18] On the contrary, APDI was shown to have the most homogenous distribution in the study by Oktay.[26]

The results of this study showed statistically significant correlation (p-value < 0.001) among seven sagittal parameters. However, the strength of association (correlation coefficient, r) varied between different pairs.

In this study, strong correlation was found between A-B plane and ANB angle (r=0.749). Good interchangeability of the FABA and AF-BF with other measures was also shown in the results. Very strong correlation of AF-BF distance with AXB and strong with FABA was found, while FABA also showed strong correlation with AXB. Weak correlation between the ANB angle and the Wits appraisal has been shown in some studies,[17,24,26] while both were moderately correlated in this study. In addition, ANB angle was found to be weakly correlated with the beta angle.

Nikolic found highly significant correlation between ANB angle, Wits assessment and NAPg angle.[28] Kirchner and William 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'.[27] Although, Oktay reported strong correlations among the ANB angle, Wits appraisal and the APDI, but he also pointed out that the Wits, AF-BF and APDI are not more reliable in clinical diagnosis than the ANB angle.[26] Another study by Ishikawa *et al.* concluded that 'higher interchangeability among the parameters was substantiated between the SN-AB angle and the AF-BF distance, as well as among the ANB angle, angle of convexity and the A-B plane angle.[24] However, the Wits appraisal and the APDI were less interchangeable with other parameters.'

Considering the bases for the geometric distortion effects in each parameter, the interchangeability between the seven parameters can be evaluated. Jacobson showed that rotational growth of the jaws, anteroposterior position of nasion, and the length and inclination of the SN plane influence the ANB angle.[14,15] Hussels and Nanda noted two additional factors affecting ANB, the vertical length from nasion to point B and from point A to point B.[9] However, few studies also concluded that the measurement least affected by environmental factors is the ANB angle.[26] The Wits appraisal is affected by occlusal plane inclination.[17,26] The rotation of the jaws can affect the A-B plane angle, ANB angle, FABA and the AF-BF distance. Although, the AXB angle may not be affected by the vertical displacement of point A, it may be affected by the vertical positioning of point B. So variability must be taken into consideration when assessing individuals and because of the possible misleading factors, it is better to use more than a single parameter for diagnosis and treatment planning.

This study used subjects with variant dentofacial characteristics so the applicability to the normal occlusion subjects was limited. Further investigation must be conducted to evaluate sagittal jaw relationship with samples including individuals with normal occlusion.

CONCLUSION

Despite varying strengths of association, statistically significant correlations were found among seven methods for assessing sagittal jaw relationship. The strongest correlation in this study was found between AXB and AF-BF distance (r=0.924). Wits appraisal showed the greatest coefficient of variability. Based on the present results, it appears that A-B plane and FABA may be used to predict the skeletal class in addition to the established ANB angle, as these correlate well with each other and other parameters used in this study including ANB.

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