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ORIGINAL ARTICLE

Comparison of popular sagittal cephalometric analyses for validity and reliability

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KEYWORDS

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Abstract *Background:* The analysis of skeletal relationships of jaws in the sagittal plane is of utmost importance in orthodontic diagnosis for which numerous lateral cephalometric analyses have emerged. None of the analyses is without flaws. Current study compares ANB, Wits appraisal, Beta angle, Yen angle and W angle for their validity and reliability in diagnosis of skeletal classes.

Methods: Pretreatment cephalograph of 209 orthodontic patients comprised of 92 males and 117 females were selected from orthodontic archives. Radiographs were traced for ANB, Wits appraisal, Beta angle, W angle and Yen angle measurements. Patients were divided into three skeletal classes i.e. class I, II and III based on measurements and incisor classification and profile recorded from their files. ANOVA was applied to check the validity of performed analyses and Cramer's correlation was performed to find out the correlation between analyses and skeletal classes.

Results: All performed analyses showed statistically significant difference in the values for all three skeletal classes $p < .05$. All measured analyses were found equally reliable in diagnosis of skeletal discrepancies.

Conclusion: All five-skeletal cephalometric sagittal analyses are reliable and can be used in orthodontic diagnosis as alternative to each other.

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1. Background

Cephalometric analysis, which is based on various angular and linear measurements is an essential part of diagnosis and treatment planning in orthodontics. Analysis of jaws in sagittal plane is a key step which was first introduced by Wylie (Wylie, 1947) in 1947. Since then many methods of assessing the jaw in AP plane have been formulated. Of these parameters the ANB angle by Riedel (Riedel, 1950) the Wits appraisal by

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Jacobson (Jacobson, 1975), and recently Beta angle stated by Baik and Ververidou (Baik and Ververidou, 2004) are the commonly used analyses. However, each analysis has its limitations and drawbacks. Angle ANB is affected by the position of nasion and jaw rotations while Wits appraisal is misled by occlusal plane orientation and erupting tooth buds. Beta angle is based on measurements using center of condyles or condylion which is also not a very reproducible landmark (Forsberg and Odenrick, 1989). Therefore, there is still a search for new analysis method that is not significantly affected by vertical variations, and is based on more reliable and reproducible structures. W angle and Yen angle are claimed to be among them, since stable landmarks like Sella, M point and G points are utilized.

Several studies have been published on ANB (Ferrazzini, 1976; Hussels and Nanda, 1984; Alam et al., 2012) and Wits appraisal (Fida, 2008; Oktay, 1991; Purmal et al., 2013). However, very few researches are found on reliability and validity of Beta angle (Qamruddin et al., 2012; Sachdeva et al., 2012). W angle and Yen angle have not been evaluated for their validity (Sachdeva et al., 2012) and never been compared with other popular analysis to check their reliability in diagnosis. The purpose of this article is to check the validity of few common sagittal analyses including newly introduced W angle and Yen angle and assess their diagnostic reliability in a sample from Pakistani population.

2. Methods

This cross-sectional study was conducted in orthodontic department of Baqai Medical University Karachi, Pakistan. Ethical approval was obtained from ethical committee of Baqai Medical University. Data included 209 pretreatment lateral cephalometric radiographs of orthodontic patients selected randomly from the department's records. Sample comprised of 92 males and 117 females, with the mean age of 17.83 years. Patients with complete permanent dentition belonging to any of the skeletal class were included in the study. Exclusion criteria were craniofacial malformations, cleft lip and palate and patients with facial asymmetry.

Tracing was done in a standard manner by single investigator for the following measurements (Fig. 1):

Angle ANB: angle between SNA and SNB.
Wits appraisal: horizontal distance between point A and B on functional occlusal plane A and point B to functional occlusal plane.
Beta angle: Angle between A and B line and a perpendicular line drawn from C-B (line that joins center of condyle and point B) to point A.
W angle: Angle between M-G line (M = midpoint of premaxilla; G = center of mandibular symphysis) and a perpendicular line drawn from point M to S-G line (S = Sella).
Yen angle: angle between S-M line and M-G line.

Patients were classified into three skeletal classes based on cephalometric measurements, incisor relationship and profile derived from patients file:

Class I: Class I incisor relationship, straight or slight convex but esthetically pleasing profile, ANB angle between 2° and 4°, Wits appraisal −3 to +3 mm(Ghani and Jabbar, 2013), Beta angle 27° to 35°, Yen angle 117° to 123°, W angle 51° to 56°.
Class II: Class II incisor relationship, convex profile, ANB > 4°, Wits appraisal > +3mm, Beta angle < 27°, Yen angle < 117°, Wangle < 51°.
Class III: Class III incisor relationship, concave profile, ANB < 2°, Wits appraisal < −3mm, Beta angle > 35°, Yen angle > 123°, W angle > 56°.

Patients who matched at least 5 criteria out of 7 were classified accordingly.

Dalhberg's (Springate, 2012) formula was applied to control the tracing errors:

$\mathbf{ME} = \sqrt{\Sigma(x1-x2)^2/2n}$ (x1 = first measurement, x2 = second measurement and n = number of repeated records). (Houston, 1983).

STROBE (Strengthening the Reporting of Observational studies in Epidemiology) was followed to design this study STROBE checklist was applied to prepare this manuscript. (Von Elm et al., 2008).

3. Statistical analysis

The data was analyzed using Statistical Package for the Social Sciences (SPSS) version 20 with confidence level set at 5% ($P < .05$). Descriptive analysis was used to calculate minimum and maximum value, mean and standard deviation. To assess the difference in measured values for all skeletal classes, Analysis of variance (ANOVA) was applied. Cramer's correlation was applied to check the reliability of all performed analyses in assessing the skeletal malocclusion in sagittal plane.

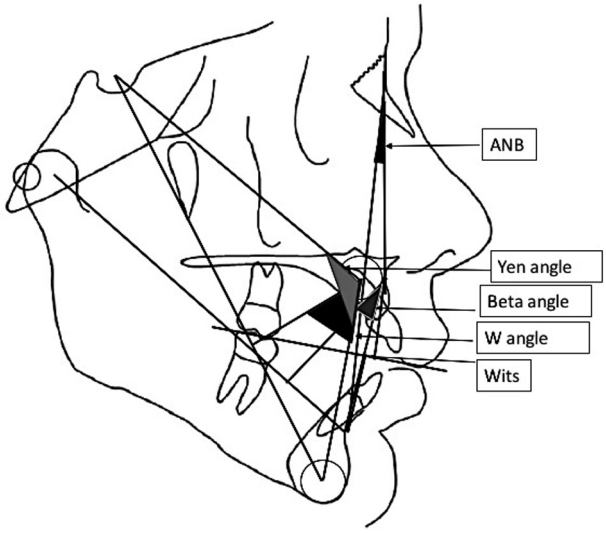

Fig. 1 Cephalometric tracing: ANB, Wits appraisal, Beta angle, W angle and Yen angle.

4. Results

Skeletal class II was the most prevalent while Class III was least prevalent malocclusion in this study. Distribution of skeletal class among males and females in this study is depicted in Table 1. Skeletal Class II and Class III was more prevalent in females, however males predominated in skeletal Class I pattern.

Mean values for ANB, Wits appraisal, Beta angle, W angle and Yen angle is shown in Table 2. ANOVA shows significant difference in all measured values among skeletal classes $p \leq 0.001$. All performed analyses were found equally reliable in the diagnosis of skeletal patterns as statistically significant correlation was found between skeletal classes and all performed sagittal analyses (Table 3).

5. Discussion

Lateral cephalometric radiograph is an extremely useful diagnostic tool in orthodontic practice was introduced in 1931 by Broadbent (Broadbent, 1931). Most of the orthodontic problems occur in sagittal plane therefore analysis of jaws in anteroposterior plane is most important (Fida, 2008). Wylie (Wylie, 1947) assessed the maxilla-mandibular relationship in sagittal plane for the first time, since that time numerous analysis have been introduced. In this study, sample was classified into three skeletal classes and measured for sagittal analyses (ANB, Wits appraisal, Beta angle, W angle and Yen angle). All measured values were compared for their validity and reliability in diagnosis.

The results of this study show that all performed analyses not only demonstrated significantly different values for all three skeletal classes ($p < .001$) but also were found equally reliable to diagnose skeletal sagittal discrepancies (Table 3).

In a previous similar study, Sachdeva found insignificant difference in the values of ANB and Wits appraisal among skeletal class I, II and III whereas all three classes were significantly different in the values of Beta angle, W angle and Yen angle (Sachdeva et al., 2012).

ANB angle is considered to be the most popular parameter to analyze the skeletal discrepancies in sagittal plane (Baik and Ververidou, 2004), though many researchers have found that reliability of ANB angle is affected by changes in SN plane mainly due to superioanterior movement of nasion with growth (Brown, 1981; Chang, 1987; Rotberg et al., 1980). Growth rotation and vertical growth also influence the interpretation of ANB (Jacobson, 1975). Conversely in this study ANB value showed high correlation with skeletal classes.

Wits appraisal is also a popular alternative which demonstrated high correlation with skeletal groups in this study. This result was in contrast with previous researches who reported difficulty in locating the functional occlusal plane that may affect diagnostic value of the analysis negatively (Ishikawa et al., 2000; Sachdeva et al., 2012).

Beta angle does not depend on cranial landmarks therefore it is claimed to be least affected by change in cranial base and jaw rotation. In this study there was significant difference in the values of Beta angle for all skeletal classes ($p < .05$) and it was also found reliable in diagnosis of skeletal malocclusion. This was supported by Baik and Ververidou (Baik and Ververidou, 2004), Fida (Fida, 2008), Qamruddin I. (Qamruddin et al., 2012), Kannan (Kannan et al., 2012) and Sachdeva (Sachdeva et al., 2012) who reported less variability in Beta angle. Doshi (Doshi et al., 2012) also found Beta angle more reliable in diagnosis of class II patients in Indian population.

Yen angle which involves Sella in its method but still it was claimed to be least affected by variations in facial height and jaw rotations (Neela et al., 2009). In this research Yen angle had high validity and reliability in diagnosis of all skeletal categories ($p < .05$). This result was very well supported by Sachdeva (Sachdeva et al., 2012) and Doshi (Doshi et al., 2012) who found Yen angle to be one of the most reliable measurement.

Table 1 Distribution of skeletal classes among genders.

Skeletal Class	Class I	Class II	Class III	Total
Males	44	36	12	92
Females	41	58	18	117
Total	85	94	30	209

Table 2 Mean, SD and p value of analyses for skeletal classes.

Analysis	Class	Mean ± SD	ANOVA p value
ANB (°)	I	3.47 ± 1.46	$<0.001^{**}$
	II	6.29 ± 1.70	
	III	−2.40 ± 4.21	
Wits (mm)	I	1.09 ± 2.49	$<0.001^{**}$
	II	4.34 ± 3.59	
	III	−6.13 ± 4.80	
Beta angle (°)	I	30.11 ± 3.49	$<0.001^{**}$
	II	26.46 ± 4.70	
	III	41.50 ± 6.83	
W angle (°)	I	54.44 ± 2.59	$<0.001^{**}$
	II	49.32 ± 5.12	
	III	62.60 ± 5.21	
Yen angle (°)	I	119.40 ± 3.51	$<0.001^{**}$
	II	113.86 ± 4.32	
	III	131.00 ± 7.80	

Table 3 Number of patients in each skeletal class according to analyses and correlation with skeletal class.

Method of analysis	ANB	Wits	Beta angle	W angle	Yen angle
No. of cases in each category					
Class I (85)	60	72	71	62	65
Class II (94)	80	59	51	77	65
Class III (30)	23	21	27	25	27
Cramer V (r value)	0.67	0.64	0.66	0.65	0.67
Significance p value	$<0.05^{*}$	$<0.05^{*}$	$<0.05^{*}$	$<0.05^{*}$	$<0.05^{*}$

W angle is relatively new angle to measure skeletal sagittal discrepancies introduced by Bhad in 2011 (Bhad et al., 2013), therefore there are very limited studies available on reliability of W angle. Sachdeva in her study compared few sagittal measurements and found W angle a very reliable method for diagnosis of AP skeletal discrepancies (Sachdeva et al., 2012). Similar result was found in our study in which W angle showed high diagnostic value in diagnosis of sagittal skeletal problems and had high correlation with other performed analyses.

5. Conclusions

- All the performed measurements ANB, Wits appraisal, Beta angle, W angle and Yen angle have statistically significant different values for skeletal class I, II and III.
- All performed analyses have equal diagnostic importance and reliability therefore can be used as alternative analyses for each other, when certain factors make the use of one analysis difficult.

Conflicting interest

None.

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