Comparison of different parameters for recording sagittal maxillo mandibular relation using natural head posture: A cephalometric study

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ABSTRACT

Background: Commonly used parameters for anteroposterior assessment of the jaw relationship includes several analyses such as ANB, NA-Pog, AB-NPog, Wits appraisal, Harvold's unit length difference, Beta angle. Considering the fact that there are several parameters (with different range and values) which account for sagittal relation, and still the published literature for comparisons and correlation of these measurements is scarce. Therefore, the objective of this study was to correlate these values in subjects of Indian origin.

Materials and Methods: The sample consisted of fifty adult individuals (age group 18-26 years) with equal number of males and females. The selection criteria included subjects with no previous history of orthodontic and/or orthognathic surgical treatment; orthognathic facial profile; Angle's Class I molar relation; clinical Frankfort Mandibular plane angle FMA of $30\pm5°$ and no gross facial asymmetry. The cephalograms were taken in natural head position (NHP). Seven sagittal skeletal parameters were measured in the cephalograms and subjected to statistical evaluation with Wits reading on the true horizontal as reference. A correlation coefficient analysis was done to assess the significance of association between these variables.

Results: ANB angle showed statistically significant correlation for the total sample, though the values were insignificant for the individual groups and therefore may not be very accurate. Wits appraisal was seen to have a significant correlation only in the female sample group.

Conclusions: If cephalograms cannot be recorded in a NHP, then the best indicator for recording A-P skeletal dimension would be angle AB-NPog, followed by Harvold's unit length difference. However, considering biologic variability, more than one reading should necessarily be used to verify the same.

Key words: Natural head position, sagittal skeletal relation, true horizontal

INTRODUCTION

An accurate anteroposterior assessment of the jaw relationship is critically important not only for orthodontic treatment but also for orthognathic surgery planning. Among various parameters which have been proposed, the commonly used ones are angle ANB,[1] NA-Pog,[2] AB-NPog,[2] Wits appraisal,[3] and Harvold's[4] unit length difference. A new measurement for assessing sagittal discrepancies also has been introduced recently as the "Beta angle."[5] The cant or inclination of all intracranial reference lines is subject to biologic variations (e.g., Sella to Nasion, Porion to Orbitale), making them unsuitable for meaningful cephalometric analysis. Many authors have pointed out the inadequacies of Frankfurt Horizontal plane, which is one of the most commonly used intracranial reference lines. In 1993, Arnett and Bergman,[6] while emphasizing the importance of clinical assessment of the face, drew attention on the fact that a patient who clinically (in natural relaxed position) is Class I, can be wrongly diagnosed as having Class II or Class III facial appearance, if the cephalometric Frankfort horizontal FH plane does not coincide with the true horizontal (TH).

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To overcome the shortcomings of various methods of orientation for cephalometrics, Downs,[7] Bjerin,[8] and Moorrees and Kean[9] introduced the concept of natural head position (NHP) in orthodontics It was observed that the variance of NHP is significantly less than the variance of intracranial reference planes to the vertical. Cephalometric analysis based on NHP, therefore is a more rational approach. Since the sagittal assessment from the measurements projected on the TH in the NHP is the most accurate, we planned to correlate this assessment with various other readings in the conventional cephalometric analyses employed for the same purpose. This correlation will indicate which of the various conventional readings for judging skeletal dysplasia are relatively more dependable.

Considering the fact that there are many values (with different ranges) which account for sagittal relation, and still the published literature for comparisons and correlation of these measurements is scarce, it was felt necessary to correlate among these values in subjects of Indian origin with pleasing facial profile and Class I dental relation. The objective of this study was to compare and evaluate the relative precision among commonly used variables for recording sagittal skeletal relation.

MATERIALS AND METHODS

This study was planned and executed in the Department of Orthodontics and Dentofacial Orthopedics, S.D.M. College of Dental Sciences and Hospital, Dharwad.

A total of 50 subjects were selected. The sample included 25 male and 25 female adult individuals. As per departmental protocol, an ethical committee clearance of the institute was taken along with an informed written consent was obtained from the subjects before entering into the study.

The criteria for selection of each sample were predetermined as under:
1.   All the subjects selected were under age group of 18-26 years in whom active growth had completed
2.   All the subjects had orthognathic facial profile
3.   All the subjects had Angle's Class I molar relation
4.   All the subjects had clinical FMA of 30±5° (which was the range of FMA considered normal by White *et al*.[10]
5.   Subjects with no gross facial asymmetry
6.   Individuals who were undergoing or had previously undergone any orthodontic and/or orthognathic surgical treatment were excluded from the study.

The lateral cephalometric radiographs were taken on a digital machine (PLANMECA PM 2002 CC PROLINE, Helsinki, Finland). The cephalograms were taken in NHP and were obtained on 10 × 8 inch diagnostic film (KODAK X-OMAT K film-EKTA speed plus). The procedure for obtaining the radiographs in NHP was adopted as described by Raju *et al*.[11] [Figure 1].

Matte lacquered polyester acetate papers (Garware Co.

India), 75 μm in thickness, were used to trace the lateral head films. The tracing was done with a 0.3 lead pencil. A single operator performed the tracing in a standardized manner to avoid errors due to inter-operator variations. The linear and angular measurements were made by using a set square and protractor with an accuracy of 0.5 mm and 0.5° respectively. Total eleven parameters were assessed. These included seven measurements which depict the relative anteroposterior maxillomandibular relationship and four measurements, which were components of the study parameters such as angle SNA, SNB to deduce angle ANB and maxillary and mandibular effective lengths to calculate Harvold's unit length difference.

Following cephalometric landmarks; planes and angles were used:

Hard Tissue Landmarks[12] [Figure 2]
1.   Sella (S)
2.   Nasion (N)
3.   TMJ (TM)

Figure 1: Procedure for obtaining the natural head position
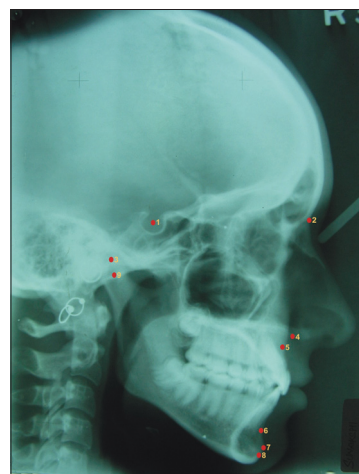

Figure 2: Hard tissue landmarks. 1. Sella (S); 2. Nasion (N); 3. TMJ (TM); 4. Anterior Nasal Spine (ANS); 5. Subspinale (A); 6. Supramentale (B); 7. Pogonion (Pg); 8. Prognathion (PGN) and 9. Centre of condyle (C)

4. Anterior Nasal Spine (ANS)
5. Subspinale (Point A)
6. Supramentale (Point B)
7. Pogonion (Pog)
8. Prognathion (PGN)
9. Centre of condyle (C)

Planes and Lines[13] [Figure 3]

1. Sella Nasion plane (S-N)
2. Occlusal plane (Occ)
3. N-A
4. N-B
5. Facial plane (N-Pog)
6. C-B
7. A-B

Some Additional Lines and Planes were used as follows
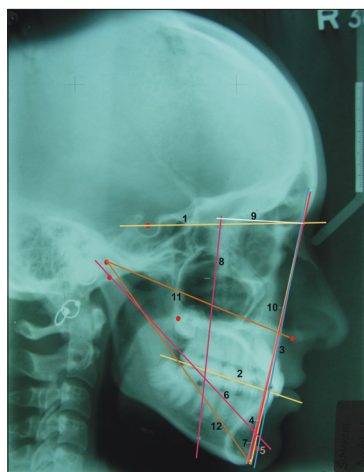
1. True vertical[14]
2. TH[11]

Figure 3: Cephalometric planes and lines. 1. Sella-Nasion plane; 2. Occlusal plane; 3. N-A line; 4. N-B line; 5. Facial plane (N-pg); 6. C-B line; 7. A-B line; 8. True verticle plane; 9. True horizontal plane; 10. N⊥ to true horizontal; 11. Maxillary effective length and 12. Mandibular effective length

Skeletal Measurements (Angles)[13,15] [Figure 4]

1. SNA
2. SNB
3. ANB
4. N-A-Pog (Angle of convexity)
5. AB-NPog
6. Beta angle[5] [Figure 5]

Linear Measurements[15,16] [Figure 6]

1. Wits appraisal
2. TH Wits[17]
3. Maxillary effective length
4. Mandibular effective length

The data were summarized as Mean±SD. Two independent groups were compared by non-parametric Mann-Whitney U test (Z adjusted) as most of the variables under consideration follow non normal distribution. Spearman rank order correlation (rho) was done to assess association of TH Wits with other variables. A two-sided ($\alpha = 2$) $P < 0.05$ was considered statistically significant.

RESULTS

In the present study, to find out any significant differences among these measurements between male and female sample, Students *t*-test was applied [Table 1]. Most of the readings showed no statistically significant differences ($P > 0.05$) between the two sexes. The individual skeletal parameters were then compared using TH-Wits as reference. This value is considered to be more reliable since it depicts the relation of points A and B to the TH; in other words, it is a measure of the subject's anteroposterior facial relationship in the pose in which he/she is generally perceived by others.

Table 2 depicts the statistical comparison between parameters using TH-Wits as reference (Total = males and females). In our study considering the entire sample, the readings showing non-significant *P* values ($P > 0.05$) were NA-Pog,
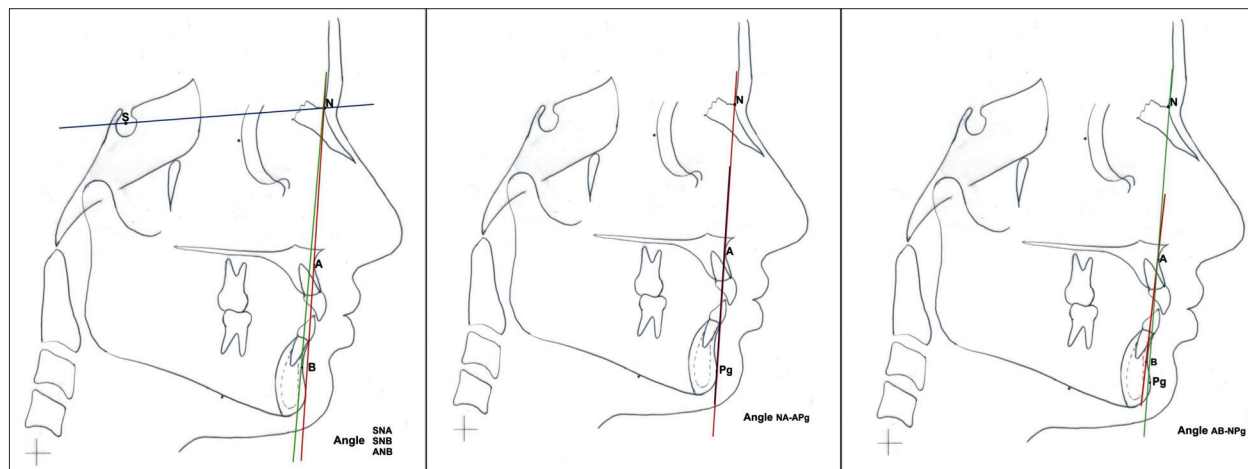

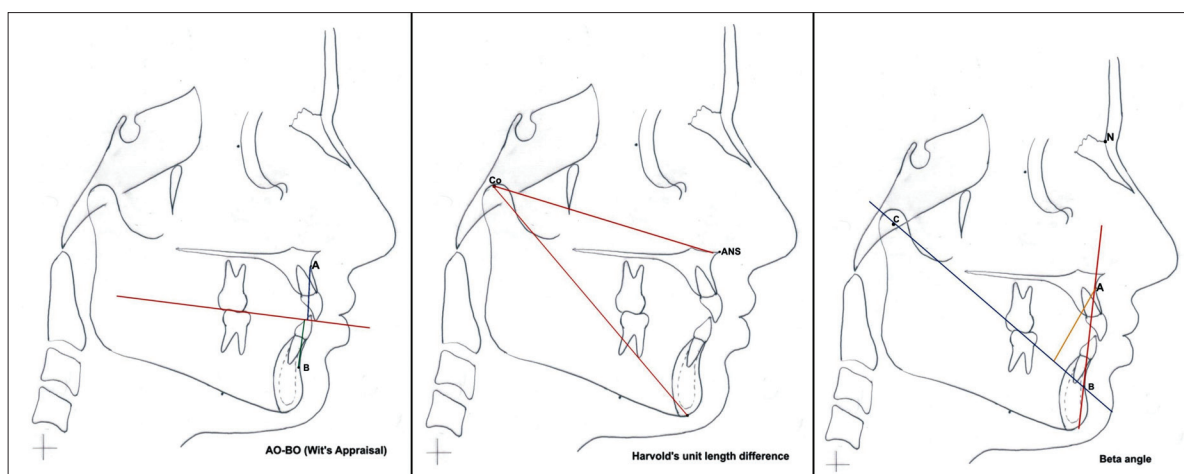**Figure 4:** Skeletal measurements (Angles)
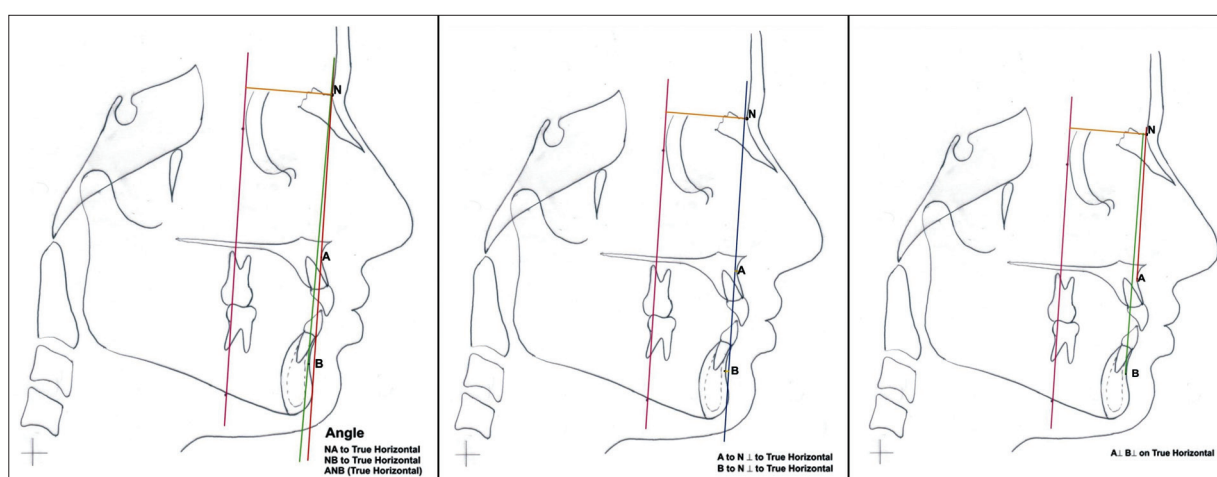
Figure 5: Skeletal measurements (Angles)

Figure 6: Skeletal measurements (Linear)

Table 1: Comparison of male and female observations by using *t*-test

Variables	Male		Female		*t* value	*P*	Significant
	Mean	Standard deviation	Mean	Standard deviation			
SNA°	83.4800	3.5369	81.3400	2.6992	2.4049	0.0201	S
SNB°	81.2400	3.0589	79.0800	2.8125	2.5991	0.0124	S
ANB°	2.2400	1.4514	2.2600	1.4586	−0.0486	0.9614	NS
NA-Pog°	3.2600	2.6853	3.6800	2.5531	−0.5668	0.5735	NS
AB-Npog°	−5.0000	2.6339	−4.6800	2.2862	−0.4588	0.6485	NS
Wits Appl. (mm)	2.3200	1.7905	1.3200	1.8136	1.9619	0.0556	NS
TH Wits (mm)	1.3480	1.7256	2.0600	1.9382	−1.3718	0.1765	NS
TM-ANS (mm)*	101.0400	3.3848	93.2400	3.5506	7.9504	0.0000	VHS
TM-PGN (mm)**	125.7200	5.1520	115.7600	4.2650	7.4458	0.0000	VHS
Harvold's Diff. (mm)	24.6800	3.7829	22.5200	3.8527	2.0002	0.0512	NS
Beta angle°	31.1600	2.9358	30.7800	2.8798	0.4620	0.6462	NS

ANS – Anterior nasal spine; PGN – Prognathion; *Maxillary effective length; **Mandibular effective length

Wits appraisal and Beta angle. This indicates that these values do not bear strong correlation with the TH-Wits. The values with which TH-Wits could be used interchangeably were values which showed significant *P* values, namely AB-NPog (highly significant) and angle ANB as well as Harvold's unit length difference (significant at 0.05). Similarly, when evaluation was done individually for the male and female samples, among male sample group non-significant *P* values (*P*>0.05) were angle ANB, NA-Pog, Wits appraisal and Beta angle [Table 3]. In female sample group angle ANB, NA-Pog, AB-N-Pog, and Beta angle were showing non-significant *P* values (*P*>0.05) while Wits Appraisal showed significant correlation with TH-Wits (significant at 0.05) [Table 4].

Table 5 showed that the level of most of the skeletal and linear measurements were comparatively higher in males as compared to females except ANB, NA-Pog and TH-Wits. Comparing the skeletal and linear measurements between the two groups, the levels of SNA, SNB, Maxillary effective length TM-ANS, Mandibular effective length TM-PGN and Harvold's Diff. in males were found significantly (*P*<0.05 or *P*<0.001) different and higher as compared to females. However, the levels of ANB, NA-Pog, AB-Npog, Wits, TH-Wits and Beta Angle did not differ (*P*>0.05) between the two genders, i.e., found to be statistically similar.

In males, AB-Npog showed significant (*P*<0.05) and negative (inverse) correlation with TH-Wits while Wits showed significant (*P*<0.01) and positive (direct) correlation with TH-Wits. Similarly, in females, AB-Npog also showed significant (*P*<0.05) and negative correlation with TH-Wits. In total (males+females) subjects, ANB showed significant (*P*<0.05) and positive correlation with TH-Wits while AB-Npog, Harvold's Diff and Beta Angle showed significant (*P*<0.05) and negative correlation with TH-Wits [Table 6].

DISCUSSION

Although ANB and Wits are cephalometric tools widely applied to evaluate AP relationships of the jaws, there is significant intrinsic lack of certainty in both assessments. This is the reason that most of the studies either correlated or compared these two values. Consequently, there is intensive search for new and better cephalometric and non-cephalometric diagnostic resources to assess jaw discrepancies. This research is needed because vital orthodontic decisions depend on correct assessments.

In the study of Rotberg *et al.*[18] the ANB and "Wits" values of fifty patients were correlated to see how accurately one can predict the "Wits" value, given the ANB measurement. There results showed no correlation between these two values when the "Wits" measurement is negative.

Järvinen[19] attempted to establish the relationship between the ANB angle and the Wits appraisal by measuring the individual variations in their reference systems, and by constructing a model of regression between them and a few parameters describing the reference systems. The results of their study indicated that approximately 93% of the variation of the Wits appraisal could be explained by the variation of the ANB, Nasion Sella Line/Occlusal line NSL/OL, and SNA angles.

Del Santo[20] observed the influence of occlusal plane inclination on the ANB angle and the Wits appraisal in 122 finished orthodontic patients' lateral cephalometric radiographs. The result showed that there was a tendency for inconsistency between ANB and Wits assessments in the high occlusal plane angle group and a tendency for consistency in the low occlusal plane angle group.

Table 2: Statistical comparison between parameters using true horizontal-Wits as reference (total=males and females)

	TH Wits (mm)		
	Correlation coefficient	*t* value	*P* value
ANB°	0.3326	2.4432	0.0183
NA-Pog°	0.2521	1.8049	0.0774
AB-Npog°	−0.3708	−2.7659	0.0080
Wits Appl. (mm)	0.0983	0.6846	0.4969
Harvold's Diff. (mm)	−0.3215	−2.3524	0.0228
Beta angle°	−0.2442	−1.7444	0.0875

TH – True horizontal

Table 3: Statistical comparison between parameters using true horizontal-Wits as reference (males)

	TH Wits (mm)		
	Correlation coefficient	*t* value	*P* value
ANB°	0.3738	1.9326	0.0657
NA-Pog°	0.2588	1.2847	0.2117
AB-Npog°	−0.4089	−2.1486	0.0424
Wits Appl (mm)	−0.1302	−0.6295	0.5352
Harvold's Diff. (mm)	−0.4256	−2.2558	0.0339
Beta angle°	−0.2401	−1.1864	0.2476

TH – True horizontal

Table 4: Statistical comparison between parameters using true horizontal-Wits as reference (females)

	TH Wits (mm)		
	Correlation coefficient	*t* value	*P* value
ANB°	0.2980	1.4971	0.1480
NA-Pog°	0.2251	1.1082	0.2792
AB-Npog°	−0.3818	−1.9813	0.0596
Wits Appl (mm)	0.4911	2.7038	0.0127
Harvold's Diff. (mm)	−0.1227	−0.5927	0.5591
Beta angle°	−0.2331	−1.1496	0.2621

TH – True horizontal

Table 5: Comparison (mean±SD) of skeletal and linear measurements between males and females by using non parametric Mann-Whitney U test

Variables	Males (*n*=25)	Females (*n*=25)	*Z* value	*P* value
SNA°	83.48±3.54	81.34±2.70	2.48	0.013
SNB°	81.24±3.06	79.08±2.81	2.32	0.020
ANB°	2.24±1.45	2.26±1.46	0.05	0.960
NA-Pog°	3.26±2.69	3.68±2.55	0.48	0.633
AB-Npog°	−5.00±2.63	−4.68±2.29	0.37	0.710
Wits (mm)	2.32±1.79	1.32±1.81	1.69	0.091
TH Wits (mm)	1.35±1.73	2.06±1.94	1.39	0.163
TM-ANS (mm)*	101.04±3.38	93.24±3.55	5.29	*P*<0.001
TM-PGN (mm)**	125.72±5.15	115.76±4.26	5.32	*P*<0.001
Harvold's Diff. (mm)	24.68±3.78	22.52±3.85	2.13	0.033
Beta angle°	31.16±2.94	30.78±2.88	0.59	0.558

ANS – Anterior nasal spine; PGN – Prognathion; *Maxillary effective length; **Mandibular effective length

In our study, we attempted to correlate six sagittal skeletal measurements including ANB and Wits appraisal with TH Wits in fifty individuals including equal number of males and

Table 6: Correlation of true horizontal Wits with skeletal and linear parameters in males, females and total (male+female) subjects by using Spearman rank correlation (rho values)

Variables	Males (*n*=25)	Females (*n*=25)	Total (males+females) (*n*=50)
SNA°	0.39	0.13	0.14
SNB°	0.23	−0.04	−0.04
ANB°	0.31	0.33	0.34*
NA-Pog°	0.09	0.24	0.22
AB-Npog°	−0.49*	−0.44*	−0.45**
Wits (mm)	0.57**	−0.03	0.22
TM-ANS (mm)*	0.39	0.28	0.07
TM-PGN (mm)**	0.20	−0.19	−0.15
Harvold's Diff. (mm)	−0.08	−0.39	−0.35*
Beta angle°	−0.26	−0.27	−0.30*

ANS – Anterior nasal spine; PGN – Prognathion; *<0.05; **$P<0.001$

females. Among entire sample, ANB was significantly correlated with TH Wits, while "Wits" showed same type of correlation in female sample group. However, highly significant correlation was seen between AB-NPog with TH Wits. So this supports the Järvinen study which showed more variation of Wits appraisal as compared to ANB angle. Therefore, if Wits appraisal is to be used, it should be used only in conjunction with other methods of assessment of apical base discrepancies and with due regards for the likely effects of changes in its component parts.

Viazis[17] published an article on comprehensive assessment of anteroposterior jaw relationship. In this, he derived the means for assessment of jaw bases using TH as a reference plane. He mentioned that TH Wits provides a clearer picture of the AP relationship of the jaws than the original Wits, which can be affected by the inclination of the occlusal plane or Frankfort Horizontal.

In our study, the mean value of TH Wits was 1.7±1.9 in the sample size of 50. The difference between this reading and that of Viazis might be because of ethnic and racial differences.

In an attempt in correlating various sagittal measurements, one study was executed by Kataria and Maheshwari[21] comparing App-Bpp and Ab-Bb sagittal parameters with the conventionally used ANB and A occlusal to B occlusal AO-BO parameters to evaluate the reliability of these parameters in the anteroposterior jaw analysis. They derived a coefficient of correlation among various sagittal parameters used in their study. Their results indicated that all the four sagittal parameters were closely related to each other and may be used interchangeably. Similar kind of correlation has been established in our study in which six sagittal parameters were correlated with TH Wits. The values with which TH-Wits could be used interchangeably were values which showed significant *P* values, namely AB-NPog, angle ANB and Harvold's unit length difference.

It is a very frequently asked and discussed question in clinical practice. Greater discussion on this subject has often caused more confusion than providing a precise answer. A perusal of

the literature reveals that there are various ways to assess the maxillo mandibular jaw discrepancy but none so far can be universally used with authenticity. Thorough research has documented that the TH reference plane has proven its superior effectiveness to SN and Frankfurt Horizontal. Therefore, it is the most reliable and clinically relevant reference line in cephalometric analysis. From the results of our present study, it can be inferred that:

i. If a cephalogram cannot be recorded in a NHP, then the best indicator for recording A-P skeletal dimension would be the angle AB-NPog, followed by the Harvold's unit length difference

ii. Although, the angle ANB showed statistically significant correlation for the total sample, the values were insignificant for the individual groups and therefore, may not be very accurate

iii. The Wits appraisal was seen to have a significant correlation only in the female sample group and therefore may be used to assess the skeletal maxillo-mandibular relationship in female patients. This, however, needs to be verified with a larger sample

iv. The Beta angle is among the latest measurements used to record the AP skeletal problem. However, based on the results of our study we could not correlate its efficacy as an indicator of skeletal discrepancy.

CONCLUSION

Results of our study showed that if cephalograms cannot be recorded in a NHP, then the best indicator for recording A-P skeletal dimension would be angle AB-NPog, followed by Harvold's unit length difference. However, considering biologic variability, more than one reading should necessarily be used to verify the same.

REFERENCES

1. Riedel RA. The relation of maxillary structures to cranium in malocclusion and in normal occlusion. Angle Orthod 1952;22:142-5.
2. Downs WB. The role of cephalometrics in orthodontic case analysis and diagnosis. Am J Orthod 1948;34:812-40.
3. Jacobson A. The "Wits" appraisal of jaw disharmony. Am J Orthod 1975;67:125-38.
4. Harvold EP. The activator in orthodontics. St. Louis: CV Mosby; 1974. p. 37-56.
5. Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: The Beta angle. Am J Orthod Dentofacial Orthop 2004;126:100-5.
6. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. Am J Orthod Dentofacial Orthop 1993;103:299-312.
7. Downs WB. Analysis of the dentofacial profile. Angle Orthod 1956;26:192-212.
8. Bjerin RA. Comparison between the Frankfort horizontal and the sella turcica-nasion as reference planes in cephalometrics analysis. Acta Odont Scand 1957;15:1-12.
9. Moorrees CF, Kean MR. Natural head position: A basic consideration in the interpretation of cephalometric radiographs. Am J Phys Anthropol 1958;16:213-34.
10. White TC, Gardiner JH, Leighton BC. Examination of the patients.

Orthodontics for Dental Students. 3rd ed. Hong Kong: Macmillan Publishers; 1976. p. 255.

11. Raju NS, Prasad KG, Jayade VP. A modified approach for obtaining cephalograms in the natural head position. J Orthod 2001;28:25-8.

12. Athanasiou AE. Anatomy, Radiographic anatomy and Cephalometric landmarks of craniofacial skeleton, soft tissue profile, dentition, pharynx and cervical vertebrae. Orthodontic Cephalometry. London: Mosby-Wolfe publication; 1995. p. 21-62

13. Rakosi T. Significance of Angular and Linear Measurements for Dentoskeletal Analysis. An Atlas and Manual of Cephalometric Radiography. London: Wolfe Medical Publications Ltd.; 1982. p. 55-8.

14. Cooke MS, Wei SH. A summary five-factor cephalometric analysis based on natural head posture and the true horizontal. Am J Orthod Dentofacial Orthop 1988;93:213-23.

15. Jacobson A. Wits Appraisal. Radiographic Cephalometry from Basics to Videoimaging. Hong Kong: Quintessence Publishing Co. Inc.; 1995. p. 97-112

16. Proffit WR, Fields HW. Orthodontic Diagnosis: The development of a problem list. Contemporary Orthodontics. 3rd ed. St. Louis: Mosby; 2000. p. 179-80.

17. Viazis AD. Comprehensive assessment of anteroposterior jaw relationships. J Clin Orthod 1992;26:673-80.

18. Rotberg S, Fried N, Kane J, Shapiro E. Predicting the "Wits" appraisal from the ANB angle. Am J Orthod 1980;77:636-42.

19. Järvinen S. Relation of the Wits appraisal to the ANB angle: A statistical appraisal. Am J Orthod Dentofacial Orthop 1988;94:432-5.

20. Del Santo M Jr. Influence of occlusal plane inclination on ANB and Wits assessments of anteroposterior jaw relationships. Am J Orthod Dentofacial Orthop 2006;129:641-8.

21. Kataria GK, Maheshwari S. An appraisal of various cephalometric parameters in the assessment of sagittal relationship between the maxilla and mandible. J Ind Orthod Soc 1999;32:83-90.

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