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ORIGINAL ARTICLE

Inconsistency between ANB Angle and Wits Appraisal in the Turkish Population

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ABSTRACT

Objective: The aim of this study was to investigate the cephalometric parameters that impair the consistency between the Wits and ANB measurements, which are used in the determination of anteroposterior jaw relationships by logistic regression analysis in the Turkish population.

Methods: This retrospective study was conducted on 207 lateral cephalometric radiographs of 100 females (mean age: 15.5±1.09 years; age range: 14.2–17.3 years) and 107 males (mean age: 15.1±0.93 years; age range: 14.1–16.9 years) obtained from the archives of the orthodontic department. Lateral cephalometric radiographs were divided into two groups according to the presence of inconsistency between the ANB angle and Wits appraisal. The cephalometric parameters that cause the inconsistency were determined using a logistic regression method with the creation of three different regression models.

Results: We found posterior rotation of the mandible (SN-MP^{0}) (OR=1.09; p=0.029) as an independent predictor of the inconsistency in Model 1. In Model 2, SN-MP^{0} (OR=1.11; p=0.016) was also found to be effective on the development of the inconsistency. In Model 3, inclination of the occlusal plane (OP-SN^{0}) (OR=1.07, p=0.02) was the independent predictor of the inconsistency.

Conclusion: An increase in SN-MP^{0} and OP-SN^{0} are effective in the development of inconsistency between the ANB and Wits appraisals in the Turkish population.

Keywords: ANB angle, Wits appraisal, consistency

INTRODUCTION

The patient-oriented approach and soft tissue paradigm change, in which clinical examination comes first, are important developments in orthodontic diagnosis and treatment planning.[1] However, various imaging methods are currently needed to quantitatively evaluate the associations between the soft and hard tissues. These include orthopantomograph (OPG), lateral cephalometric radiographs, and anteroposterior radiographs. In addition, although the use of cone beam computed tomography (CBCT) has recently become the subject of debate, its use is recommended only in some abnormalities and not routinely because of the radiation dose it causes. Cephalometric analysis is currently used as one of the basic diagnostic instruments that have long been used by orthodontists.[2-4]

The ANB angle, defined by Steiner, is frequently used in the assessment of anteroposterior upper and lower jaws relationships. The angle between the planes crossing the nasion-A points and nasion-B points is called the ANB angle. Jacobson[5] suggested that the antero-posterior and vertical position of the nasion point and the rotational changes of the jaws influence the reliability of the ANB angle and thus recommended the use of Wits appraisal. Contrary to other parameters, Wits appraisal is not related to the skull base and nasion point. Instead, this measurement is defined as the distance between the lines drawn from the A and B points coming perpendicular to occlusal plane. However, it is suggested that the occlusal plane is affected by tooth eruption and dental development.[6-8] To overcome the disadvantages of both methods, Bishara et al.[9] suggested using both methods together. How-

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ever, although the ANB and Wits methods are expected to result in similar measurements, the correlation between them may be impaired in some circumstances.[9-12] The diagnosis and planning treatment also become more difficult in situations in which the consistency between the two measurements is lacking.

The aim of the present study was thus to investigate the cephalometric parameters that impair the consistency between the Wits and ANB measurements, which are used in the determination of anteroposterior jaw relationships by logistic regression analysis in the Turkish population.

METHODS

This retrospective study was conducted on 207 lateral cephalometric radiographs of 100 females (mean age: 15.5±1.09 years; age range: 14.2-17.3 years) and 107 males (mean age: 15.1±0.93 years; age range: 14.1-16.9 years) obtained from the archives of the Gülhane Military Medical Academy, Department of Orthodontics. Inclusion criteria to the study included Turkish patients, the presence of no significant medical history and no history of trauma, no deformity in the nasomaxillary complex, and no previous orthodontic or prosthodontic treatment, or maxillofacial or plastic surgery.

To define the range of inconsistency between the ANB angle and Wits appraisal in the Turkish population, the ANB angle was determined as 2.43°±1.67 and 2.87°±1.63 in females and males, respectively.[13] For the Wits appraisal in the Turkish population, -0.71±2.05 mm and 0.28±2.20 mm were accepted in females and males, respectively.[14] A total of 207 lateral cephalometric radiographs were divided into two groups, namely subgroups of "*inconsistency +*" and "*inconsistency –*." Analyses were performed in the subgroups with inconsistency *(Inconsistency +, n: 105)* and without inconsistency *(Inconsistency -, n: 102)*. Each gender was evaluated separately. Conditions in which the measurements were in the ranges of these norms or when both parameters were deviated similarly positively or negatively from the norm values were defined as consistency between the ANB angle and Wits appraisal *(Inconsistency -)*. If only one parameter is not in the norm ranges or both measurements were deviated in opposite directions, as positive or negative, then it was defined as a presence of inconsistency *(Inconsistency +)* between the ANB angle and Wits appraisal.

The lateral cephalometric radiograph of each subject was taken with the same device (Kodak 8000C; Eastman Kodak Company, Rochester, NY, USA). All the subjects were positioned in the cephalostat with the sagittal plane at a right angle to the path of the X-rays, the Frankfort plane parallel to the horizontal, the teeth in centric occlusion, and the lips lightly closed.

Cephalograms were traced and measured by hand, and all the measurements were performed by same investigator. Twelve angular and eight linear measurements were performed in all the cephalometric radiographs (Table 1). The image magnification of the cephalostat for this study was 10%, and all the linear measurements were adjusted accordingly.

Table 1. Definition of the skeletal and dental measurements used for cephalometric analysis. *The functional occlusal plane (op) was the horizontal line from the posterior most occlusal contact of the last fully erupted mandibular molars extending anteriorly to the anterior most occlusal contact of the fully erupted premolars

Variables	Definition
SNA (°)	Angle determined by points Sella, Nasion, and A
SNB (°)	Angle determined by points A, Nasion, and B
ANB (°)	Angle determined by points A, Nasion, and B
Wits (mm)	Distance between the projections of point A and B onto functional occlusal plane
A-NP (mm)	Distance from point A to NP line (perpendicular to FH plane from point Nasion)
Pg-NP (mm)	Distance from point Pg to NP line (perpendicular to FH plane from point Nasion)
SN (mm)	Distance between the Sella and Nasion points
N-S-Ar (°)	Angle determined by points Nasion-Sella-Articulare
Ar-Go-Me (°)	Angle determined by points Articulare-Gonion-Menton
Y axis (°)	Angle formed by the intersection of Sella-Gnathion plane and FH plane
PP-SN (°)	Angle formed by the intersection of palatal plane and SN plane
OP-SN (°)	Angle determined by SN plane and functional occlusal plane*
MP-SN (°)	Angle determined by SN plane and mandibular plane
PP-MP (°)	Angle determined by palatal plane and mandibular plane
EfMX (mm)	Effective maxillary length
EfMD (mm)	Effective mandibular length
N-Me (mm)	Facial height: Distance between points Nasion and Menton
N-ANS (mm)	Upper facial height: Distance between points Nasion and ANS
U1-SN (°)	Angle formed by the intersection of upper incisor axis to SN plane
L1-MP (°)	Angle formed by the intersection of lower incisor axis to mandibular plane

Statistical Analysis

Statistical analysis was performed with Statistical Package for the Social Sciences software version 20.0 (IBM SPSS Statistics; Armonk, NY, USA). A correlation matrix was performed to detect the multicollinearity between the parameters of measurements before the logistic regression analysis. Parameters that were defined to have a correlation of equal and higher than 0.8 ($r \geq 0.8$) (PP-SN° and PP-MP°) were excluded from the regression analysis (Table 2). We investigated the effects of the variables on the ANB angle and Wits appraisal inconsistency by calculating the odds ratios (OR) with a univariate analysis for all the cephalometric analyses. Variables that have a *P*-value ≤0.20 in univariate logistic regression analysis were identified as potential risk parameters and included in the full model. We reduced the model by using backward elimination and we eliminated potential risk markers

Table 2. Correlation matrix of cephalometric measurements

Variables	A-NP (mm)	Pg-NP (mm)	SN (mm)	N-S-Ar (°)	Ar-Go-Me (°)	Y axis (°)	PP-SN (°)	OP-SN (°)	SN-MP (°)	PP-MP (°)	EfMX (mm)	EfMD (mm)	N-Me (mm)	N-ANS (mm)	U1-SN (°)	L1-MP (°)
A-NP (mm)	1															
Pg-NP (mm)	-0.470	1														
SN (mm)	0.350	0.540	1													
N-S-Ar (°)	0.249	0.108	0.370	1												
Ar-Go-Me (°)	-0.230	0.156	-0.060	0.617	1											
Y axis (°)	0.054	0.795	0.830	0.251	0.037	1										
PP-SN (°)	0.082	-0.069	0.006	0.031	-0.099	-0.042	1									
OP-SN (°)	-0.087	-0.042	-0.088	0.019	0.014	-0.072	0.056	1								
SN-MP (°)	-0.090	0.074	-0.005	-0.043	0.095	0.045	-0.999	-0.074	1							
PP-MP (°)	0.083	-0.070	0.002	0.040	-0.092	-0.046	-0.999	0.063	-0.999	1						
EfMX (mm)	-0.767	0.283	-0.514	-0.200	0.328	-0.156	-0.029	-0.018	0.035	-0.028	1					
EfMD (mm)	0.583	-0.464	0.137	0.089	-0.171	-0.059	0.018	0.127	-0.020	0.017	-0.719	1				
N-Me (mm)	-0.262	-0.245	-0.493	-0.216	-0.086	-0.471	0.061	0.147	-0.066	0.061	0.309	-0.423	1			
N-ANS (mm)	0.206	-0.165	-0.114	0.066	0.022	-0.171	0.012	-0.149	-0.022	0.026	-0.177	0.039	-0.407	1		
U1-SN (°)	-0.002	-0.079	0.006	0.188	0.129	-0.067	-0.017	0.229	0.018	-0.022	0.089	-0.206	0.087	-0.046	1	
L1-MP (°)	-0.269	0.283	0.052	-0.285	-0.130	0.136	-0.021	-0.154	0.029	-0.021	-0.003	-0.007	-0.054	0.029	-0.404	1

by using likelihood ratio tests. Three different models were created for the multivariate logistic regression. All the parameters with a significance level of ≤0.20 were included in the first model. The occlusal plane angle (OP-SN°) was excluded, and the analysis was repeated in the second model. In the third model, SN-MP° was excluded and a regression analysis was performed on the rest of the parameters. A statistical significance (alpha) level of 0.05 was used for all the statistical analyses. To evaluate the intra-examiner reliability, the measurements were repeated on 20 cephalometric radiographs, which were randomly chosen one month after the first measurements. All the evaluations with all the parameters were performed using an intra-class correlation coefficient.

RESULTS

All the parameters were distributed in a wide range, and the distribution of the parameters among the two groups was similar. The means, standard deviations, and minimal and maximal values of distributions of the parameters measured in the subgroups are shown in Table 3 and Table 4, respectively. Intra-examiner reliability of the measurements (ICC) was high, i.e., between 0.991 and 0.995.

Data for all the groups were combined, and 14 variables were subjected to statistical analysis as a predictor of the inconsistency. As shown in Table 5, OP-SN° (OR=1.07, p=0.02) and SN-MP° (OR=1.10, p=0.006) were found to predict the inconsistency between the ANB angle and Wits appraisal in univariate logistic regression analysis. The cephalometric measurement parameters defined below were found to be effective in the ANB angle-Wits appraisal inconsistency by backward multivariate regression analysis performed by creating three different regression mod-

Table 3. Minimum, maximum, mean, and standard deviation (SD) of cephalometric measurements in the "*Inconsistency –*" subgroup

Variables (n=102)	Minimum	Maximum	Mean	SD
SNA (°)	71.7	89.2	80.1	3.0
SNB (°)	69.4	86.7	77.3	3.0
ANB (°)	-1.4	7.8	2.8	1.6
Wits (mm)	-10.8	12.0	0.4	2.6
A-NP (mm)	-10.4	8.6	0.2	2.6
PG-NP (mm)	-19.2	8.0	-3.5	5.1
SN (mm)	59.7	131.3	70.8	7.3
N-S-Ar (°)	110.0	137.3	123.5	5.5
Ar-Go-Me (°)	117.2	143.3	127.6	5.4
Y axis (°)	51.2	68.2	59.0	3.0
PP-SN (°)	-1.7	15.2	7.7	3.0
OP-SN (°)	6.1	22.3	16.3	3.4
MP-SN (°)	23.7	42.2	33.8	4.0
PP-MP (°)	16.6	35.4	27.0	4.1
EfMX (mm)	74.5	164.7	89.6	9.3
EfMD (mm)	95.3	206.2	115.8	12.3
N-Me (mm)	96.4	212.3	117.6	13.2
N-ANS (mm)	42.3	96.8	52.7	6.2
U1-SN (°)	84.5	122.6	102.5	6.5
L1-MP (°)	74.1	113.1	95.4	7.2

SD: standard deviation

Table 4. Minimum, maximum, mean, and standard deviation (SD) of cephalometric measurements in the "*Inconsistency* +" subgroup

Variables (n=105)	Minimum	Maximum	Mean	SD
SNA (°)	70.7	86.2	79.6	3.5
SNB (°)	66.7	83.4	76.7	3.1
ANB (°)	-1.1	8.4	2.9	1.9
Wits (mm)	-7.0	8.1	-0.2	3.4
A-NP (mm)	-10.3	8.1	-0.3	3.2
Pg-NP (mm)	-22.4	9.5	-4.6	5.7
SN (mm)	60.8	121.0	71.1	6.1
N-S-Ar (°)	108.1	137.9	123.1	4.9
Ar-Go-Me (°)	115.5	139.2	128.6	5.0
Y axis (°)	52.6	69.1	59.5	3.0
PP-SN (°)	-3.8	15.5	7.6	3.5
OP-SN (°)	5.4	26.5	17.6	4.8
MP-SN (°)	24.2	46.7	35.4	4.1
PP-MP (°)	18.0	37.6	27.8	4.3
EfMX (mm)	74.4	156.4	89.0	8.6
EfMD (mm)	97.8	193.0	115.7	11.2
N-Me (mm)	96.6	203.2	118.4	11.3
N-ANS (mm)	44.2	94.6	52.6	5.5
U1-SN (°)	87.5	118.6	101.3	6.2
L1-MP (°)	78.1	108.8	94.2	6.2

SD: standard deviation

Table 5. Effects of various variables on the ANB-Wits inconsistency based on univariate logistic regression analysis

	Univariate		
Variables	Unadjusted odds ratio	95% CI	p
A-NP (mm)	0.95	0.85-1.04	0.20
Pg-NP (mm)	0.96	0.91-1.01	0.15
SN (mm)	1.00	0.96-1.05	0.74
N-S-Ar (°)	0.99	0.93-1.04	0.61
Ar-Go-Me (°)	1.04	0.98-1.09	0.14
Y axis (°)	1.1	0.96-1.16	0.20
OP-SN (°)	1.07	1.02-1.15	0.02*
SN-MP (°)	1.1	1.02-1.18	0.006**
EfMX (mm)	0.99	0.96-1.02	0.60
EfMD (mm)	0.99	0.97-1.02	0.89
N-Me (mm)	1.00	0.98-1.02	0.63
ANS-Me (mm)	1.01	0.97-1.05	0.39
U1-SN (°)	0.97	0.93-1.01	0.18
L1-MP (°)	0.97	0.93-1.01	0.20

CI: confidence interval; *p<0.05; **p<0.01

els. All the parameters with p≤0.20 as a result of univariate analysis in Model 1 were included in regression analysis and were analyzed together. As a result of this analysis, the SN-MP° (OR=1.09, p=0.029) angle was also found to be a predictor of this inconsistency. Similarly, SN-MP° (OR=1.11, p=0.016) was determined to be the predictor of the inconsistency in Model 2. In Model 3, on the other hand, different from the previous models, OP-SN° (OR=1.07; p=0.02) was found to predict the inconsistency between the ANB angle and Wits appraisals (Table 6).

DISCUSSION

The anteroposterior relationship of the maxillary and mandibular apical bases is an important factor that should be taken into account during orthodontic diagnosis and treatment planning.[9] The ANB angle and Wits appraisal are the most frequently used parameters to assess the anteroposterior associations of the jaws. However, these two measurements have some disadvantages. Although the ANB angle has long been used in detecting the maxillo-mandibular anteroposterior skeletal relationship, it is affected by many factors, such as age of the individual,[9, 15] location of the N point and rotation of the S-N plane,[5, 7, 8, 10, 16, 17] jaw rotations,[17] inclination of the occlusal plane,[7] and severity of the face prognatism.[7,18] Similarly, the fact that Wits appraisal has its references from the dental points and is thus affected by the movements of tooth eruption and vertical growth of the alveolar process decreases the reliability of the measurement.[10]

According to Hwang et al.,[19] interpretation of dentofacial associations and cephalometric analyses should be different in distinct ethnic and racial groups. In addition, cephalometric values differ according to gender. Basciftci et al.[13] evaluated the Steiner norms in Turkish individuals and the mean ANB angle was measured as 2.87°±1.63 and 2.43°±1.67 in females and males, respectively. Gazilerli[14] evaluated the Wits appraisal in a Turkish population and defined the mean value to be -0.71±2.05 mm and 0.28±2.20 mm in females and males, respectively. The groups of inconsistency + and inconsistency - were created according to these measurements in this present study. Fishman[20] stated that changes in a wide range in the craniofacial structure might be seen in individuals with normal occlusion. Similarly, in our study, the skeletal structures demonstrated great variability in the individuals included in the study (Tables 3, 4).

ANB angle and Wits appraisal were observed to be inconsistent in some cases in cephalometric evaluations. The inconsistent results of these two measurements may cause different sagittal diagnostic results to occur. In this study, the parameters of cephalometric measurement that might cause inconsistency between these two measurements were determined in the Turkish popuation using logistic regression analysis. In this regard, assessments were performed by defining the presence or absence of inconsistency based on the previously determined Turkish norms for ANB angle and Wits appraisal. According to the results of three different regression models, the mandibular plane angle (SN-MP°), which is associated with the vertical growth of the mandible, and the occlusal plane angle

Table 6. Effects of various variables on the ANB-Wits inconsistency based on three different models of multivariate logistic regression analysis

	Multivariate								
	Model 1			Model 2			Model 3		
Variables	Adjusted odds ratio	95% CI	p	Adjusted odds ratio	95% CI	p	Adjusted odds ratio	95% CI	p
A-NP (mm)	0.96	0.82-1.12	0.6	0.97	0.83-1.13	0.67	0.96	0.83-1.12	0.67
Pg-NP (mm)	0.97	0.87-1.09	0.64	0.97	0.87-1.08	0.57	0.98	0.87-1.09	0.73
SN (mm)									
N-S-Ar (°)									
Ar-Go-Me (°)	0.99	0.92-1.06	0.82	0.99	0.92-1.06	0.82	1.01	0.95-1.07	0.61
Y axis (°)	0.94	0.80-1.11	0.48	0.93	0.79-1.10	0.43	0.98	0.84-1.14	0.83
OP-SN (°)	1.06	0.93-1.14	0.55				1.07	1.01-1.15	0.02*
SN-MP (°)	1.07	1.02-1.17	0.03*	1.11	1.02-1.19	0.016*			
EfMX(mm)									
EfMD (mm)									
N-Me (mm)									
ANS-Me (mm)									
U1-SN (°)	1.00	0.94-1.06	0.86	1.00	0.95-1.06	0.95	1.00	0.94-1.06	0.88
L1-MP (°)	0.98	0.93-1.04	0.62	0.97	0.92-1.02	0.70	0.97	0.92-1.03	0.40

CI: confidence interval; *p<0.05

(OP-SN°) were effective in the development of inconsistency. An increase in the SN-MP° angle was observed to increase the possibility of inconsistency by 1.1, and therefore an increase in the posterior rotation of the mandible was observed to cause the development of inconsistency. However, the SN-Y-axis angle was not found to be significant in this interaction. Millet et al.[21] stated that there was no statistically significant correlation between ANB and SN-Y-axis angles. According to Nanda,[15] there was no [6-8,16,17,22] was also observed to increase the possibility of inconsistency between the ANB angle and Wits appraisal by 1.07. Sherman et al.[23] noted that changes in the Wits appraisal occurring during growth are not necessarily due to changes in the sagittal jaw relationship and are liable to be affected by changes in the angulation of the occlusal plane. There is also an influence of the occlusal plane angle and facial height on the ANB angle assessment.[7] Also, the Wits appraisal is influenced by the occlusal plane angle. Chang[8] showed that the Wits appraisal is affected by the vertical dimensions of the jaws and the occlusal plane angle. According to Del Santo,[24] ANB and Wits measurements were associated with properties of the vertical direction. In addition, the ANB° might have overestimated the anteroposterior position of the jaws or Wits appraisal might have underestimated the anteroposterior position of the jaws in individuals with increased inclination of the occlusal plane; therefore, consistency decreased in cases with an increased occlusal plane angle. In a study by Erdogan[25] in which the association of the value of Wits appraisal and vertical face dimensions was analyzed using multidirectional regression analysis, the ANB angle increased with the decrease in vertical dimension; however, not at a significant level. As a result of these studies stated above, the changes in the vertical dimension affected the ANB angle and Wits appraisal differently. This effect plays an important role in the development of an inconsistency between these two measurements. This is seen as one of the causes of the results that we obtained in the present study. Tanaka and Sato[26] reported that occlusal plane inclination is substantially dependent on the growth in the vertical direction of the posterior alveolar region. Those investigators concluded that facial type also affected ANB and Wits measurements; however, it did not affect the correlation between these measurements. Gazilerli[14] calculated the correlation coefficient between the Wits appraisal and ANB angle in the Turkish population to be 0.583 and 0.62 for females and males, respectively. When the SN-MP and OP-SN angles were evaluated together in our study, the OP-SN angle was found to be ineffective on the development of an inconsistency. An increase in the vertical facial dimension, which also causes an increase in the inclination of occlusal plane, is suggested to be the cause of this situation.

CONCLUSION

It has known that ANB and Wits appraisals have their own disadvantages. An increase in posterior rotation of the mandible (SN-MP°) and inclination of the occlusal plane (OP-SN°) are seen to be effective in the inconsistency between the ANB and Wits appraisals in the Turkish population. During cephalometric assessment of the sagittal relationship between the maxilla and mandible, clinicians should also consider the vertical cephalometric measurements, especially the SN-MP and OP-SN angles, when inconsistency is observed between the ANB angle and Wits appraisal.

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