Predictability of MKG & Tau angle and their Correlation with ANB angle, W angle, Yen angle, Beta angle, and WIT'S appraisal in Central Indian Population

Abstract:
For orthodontic diagnosis and treatment planning there are various ways to assess the jaw discrepencies. Using various parameters such as ANB, Wit's appraisal, Beta, Yen, and W angles, with some limitations. To overcome these, MKG angle and Tau angle were proposed.
Aim and objective: The present study assesses the predictability of MKG and Tau angle and its correlation with previous parameter.
Materials and methods: A total of 105 lateral cephalograms were selected. Samples were divided into, Class I, Class II and Class III based on ANB angle. WITS appraisal, Beta angle, Yen angle, W angle, MKG angle and Tau angle were also measured. Kruskal-wallis test, followed by post hoc tuckey analysis and correlation coefficient analysis were done to assess the significance of association between these parameters.
Results: Tau angle and Beta angle were noted to be most predictable for differentiating Class I, Class II and Class III, MKG angle was found to be less predictable for differentiating samples.
Conclusion: Tau angle can be used along with ANB and Beta angle for assessing sagittal jaw relationship.

Key-words: Beta angle, MKG angle, Tau angle, W angle, Yen angle.

Introduction:

For orthodontic diagnosis and treatment planning, there are various ways to assess the jaw discrepancies, and one of the most widely used two-dimensional tools is the cephalometric radiograph. It is used to assess the jaw relationship in the transverse, sagittal, and vertical planes. Among them, sagittal is one of the major problems that are encountered by orthodontists, which makes sagittal discrepancy evaluation very important [1]. For treatment planning, a critical evaluation of the sagittal jaw relationship is needed, and to assess it accurately, many researchers integrated the linear and angular measurements. Evaluation of the sagittal relationship between maxilla and mandible is difficult as growth influences the position of point A and point B, jaw rotation, and vertical relationship among jaws and planes, and hence different methods have been proposed for its accurate evaluation [1, 2]. For this, Down's proposed the A-B plane angle in 1956, and after that, Riedel gave the ANB angle for assessing the sagittal jaw relationship [3]. To substitute the ANB angle, Jacobson[4] came up with the WITS appraisal. It

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links the points A and B to a decisive occlusion plane, and the space present between points AO and BO is determined to explain the jaw relationship. Later, in 2004, Baik and Ververidou [5] proposed the beta angle by combining three skeletal landmarks: point A, point B, and the condyle axis point C. But in a few cases, the condyle is not visible clearly for the reason that Neela et al.[6] gave the Yen angle. The Yen angle was introduced to eliminate the problems related to locating points A, B, and C in the occlusal plane. Whereas some cases demonstrated that jaw rotation could mask the identification of true sagittal dysplasia, Bhad et al. [7] proposed the W angle, which indicates true sagittal dysplasia that is not affected by growth rotation.

In other words, we can say that the sagittal jaw relationship is very important for patients, and many researchers have introduced linear and angular cephalometric parameters, for example, ANB angle, Beta angle, WITS appraisal, W angle, and Yen angle. But all these parameters have some limitations, and to overcome those shortcomings, MKG angle and Tau angle were proposed by Chachada [8] and Gupta et al.[9] respectively. Hence, in the present work, our objective is to check the diagnostic validity of the newly introduced MKG angle and Tau angle and review their correlation with previously proposed parameters for assessing sagittal discrepancies among the Central Indian population.

Materials and Methods:

Source of data:

This study was conducted on patients who visited the Department of Orthodontics and Dentofacial Orthopedics at our institute, and ethical approval was obtained. A standardized lateral cephalogram of pre-treated patients was taken individually and traced by a single operator to minimize inter-operator variation.

Inclusion criteria:

1. The ANB angle of patients is considered between 1° and 4° for the Class I skeletal pattern, more than 4° for the Class II pattern, and less than or equal to 0° for the Class III pattern.
2. Patients have no missing teeth and have permanent dentition.
3. Patient who had never received any orthodontic treatment.
4. No craniofacial malformations or facial disfigurement.
5. High-quality pretreatment cephalometric radiographs

Exclusion criteria:

1. Patient who had undergone orthodontic and/or orthognathic surgical treatment
2. Patients with congenital defects and any marked facial deformity
3. Medically compromised patients.

A total of 105 pre-treated patients' lateral cephalograms have been selected who fulfilled the above mentioned inclusion criteria. All the selected samples have been divided into three groups, which are: Class I, Class II, and Class III, on the basis of their skeletal relationship according to ANB angle, which resulted in a total of 35 individuals in each group. Then these cephalograms have been traced and measured for ANB angle, WITS appraisal, Beta angle, Yen angle, W angle, MKG angle, and Tau angle for each patient in the following manner:

ANB angle: Construction of the ANB angle is clearly illustrated in figure 1, showing the angle between the NA and NB line [3].

WITS appraisal: It is the measured distance between AO and BO, as indicated in figure 2. Basically, WITS is a linear parameter in which a perpendicular line is drawn from point A to B on the occlusal plane [4].

Beta angle: A perpendicular is drawn from point A to the CB line, and the angle between the AB line and perpendicular line is the beta angle [5] as shown in figure 3.

Yen angle: Construction of the Yen angle can be seen in figure 4, which requires three reference points, S, M, and G connections, and the angle measured at M is the Yen angle [6].

W angle: To construct the W angle [7], draw a perpendicular line from point M to the SG line, as shown in figure 4, and the angle formed by the SG and MG lines is the W angle.

MKG angle: To construct the MKG angle [8], three cephalometric landmarks are used, which are: M point, G point, and KR point. KR outline, lowest point. Two lines are drawn connecting the point M to KR and the point KR to G and form the MKG angle as clearly indicated in figure 6.

Tau angle (τ): The construction of τ angle can be seen in figure 5. It uses three skeletal reference points, which are point M, point G, and point T. Point T is the uppermost point at the interjection of the tuberculum sellae and the frontal wall of the pituitary fossa. Two lines are drawn connecting the point T to G and the point M to G and form a Tau angle [9].

Statistical Analysis:

The data was collected and tabulated in the excel sheet. The data have been analyzed using the SPSS (Statistical Package for Social Sciences) 21.0 version. The data have been analyzed for probability distribution using the Kolmogorov-Smirnov test (table 4). A p value of<0.05 indicated that the data was not normally distributed, so non-parametric significance tests was used. The descriptive statistics have been performed. The inter-group comparison was done using the Kruskal-Wallis test, followed by post hoc Tucker analysis as listed in tables 1 and 2. The correlation between the variables have been analyzed using Spearman's correlation coefficient (table 3).

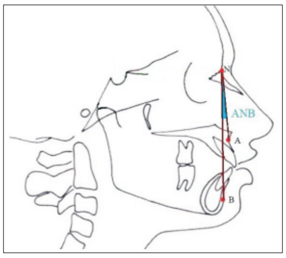

Figure 1: ANB angle

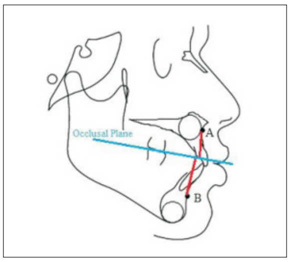

Figure 2: WITS appraisal

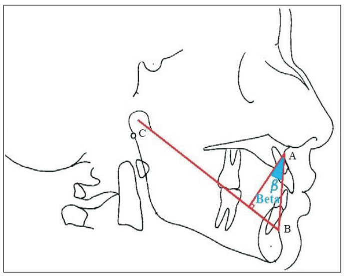

Figure 3: Beta angle

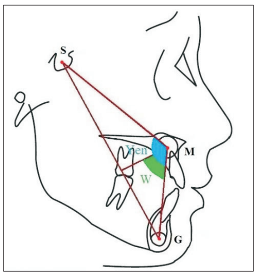

Figure 4: Yen angle and W angle

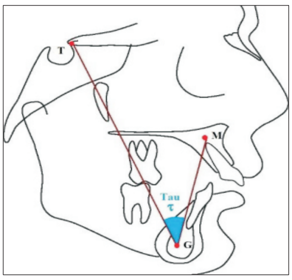

Figure 5: Tau angle

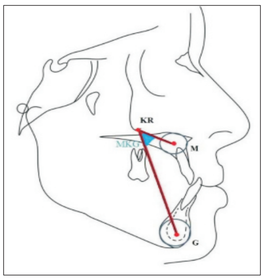

Figure 6: MKG angle

Table 1. Comparison of different variables amongst patients with class I, II and III malocclusion

		CLASS I	CLASS II	CLASS III	Chi-square value	P value[a]
MKG angle	Median	57.0000	61.0000	40.0000	70.000	<.001*
	Inter- quartile range	52.00-60.00	59.00-64.00	33.00-48.00		
TAU angle	Median	31.0000	36.0000	23.0000	92.187	<.001*
	Inter- quartile range	30.00-33.00	35.00-39.00	21.00-26.00		
ANB angle	Median	3.0000	7.0000	5.0000	60.029	<.001*
	Inter- quartile range	2.00-4.00	6.00-8.00	4.00-7.00		
BETA angle	Median	30.0000	23.0000	43.0000	92.471	<.001*
	Inter- quartile range	28.00-33.00	18.00-26.00	41.00-48.00		
YEN angle	Median	122.0000	116.0000	141.0000	84.574	<.001*
	Inter- quartile range	120.00-125.00	113.00-118.00	137.00-146.00		
W angle	Median	54.0000	50.0000	66.0000	81.056	<.001*
	Inter- quartile range	53.00-57.00	50.00-52.00	64.00-69.00		
WITS APPRAISAL	Median	1.0000	4.0000	8.0000	86.058	<.001*
	Inter- quartile range	1.00-1.500	3.00-5.00	7.00-9.00		

[a]Kruskal-wallis test. *p value<.05 was considered statistically significant.

Table 2. Post hoc analysis.

	CLASS I vs CLASS II	CLASS I vs CLASS III	CLASS II vs CLASS III
MKG angle	<.05*	<.001*	<.001*
TAU angle	<.001*	<.001*	<.001*
ANB angle	<.001*	<.001*	<.05*
BETA angle	<.001*	<.001*	<.001*
YEN angle	<.001*	<.001*	<.001*
W angle	<.001*	<.001*	<.001*
WITS APPRAISAL	<.001*	<.001*	<.001*

*p value<.05 was considered statistically significant.

Table 3. Correlation of MKG and Tau angle with different variables amongst patients with class I, II and III malocclusion.

	Variables		Spearman's correlation coefficient	P value
Class I	MKG angle	ANB angle	.293	>.05
		BETA angle	-.027	>.05
		YEN angle	-.097	>.05
		W angle	-.175	>.05
		WITS appraisal	-.212	>.05
	Tau angle	ANB angle	.393	<.05*
		BETA angle	.004	>.05
		YEN angle	-.083	>.05
		W angle	-.299	>.05
		WITS appraisal	-.115	>.05
		MKG angle	.513	<.05*
Class II	MKG angle	ANB angle	.453	<.05*
		BETA angle	-.039	>.05
		YEN angle	-.509	<.05*
		W angle	.262	>.05
		WITS appraisal	.334	>.05
	Tau angle	ANB angle	.074	>.05
		BETA angle	.130	>.05
		YEN angle	-.015	>.05
		W angle	.141	>.05
		WITS appraisal	.193	>.05
		MKG angle	.050	>.05
Class III	MKG angle	ANB angle	-.310	>.05
		BETA angle	-.295	>.05
		YEN angle	-.151	>.05
		W angle	-.364	<.05*
		WITS appraisal	-.358	<.05*
	Tau angle	ANB angle	-.771	<.001*
		BETA angle	-.726	<.001*
		YEN angle	-.800	<.001*
		W angle	-.838	<.001*
		WITS appraisal	-.155	>.05
		MKG angle	.445	<.05*

*p value<.05 was considered statistically significant.

Table 4.Predictivity of different variables amongst patients with class I, II and III malocclusion.

Variable	Predictive accuracy	Class I	Class II	Class III
MKG angle	Sensitivity	71.4%	74.3%	94.3%
	Specificity	84.2%	84.3%	100.0%
	Positive predictive value	69.4%	70.3%	100.0%
	Negative predictive value	85.5%	86.7%	95.9%
Tau angle	Sensitivity	100.0%	91.4%	97.1%
	Specificity	94.3%	100.0%	100.0%
	Positive predictive value	89.7%	100.0%	100.0%
	Negative predictive value	100.0%	95.9%	98.6%
Beta angle	Sensitivity	88.6%	100.0%	100.0%
	Specificity	100.0%	100.0%	94.3%
	Positive predictive value	100.0%	100.0%	89.7%
	Negative predictive value	94.6%	100.0%	100.0%
Yen angle	Sensitivity	54.3%	57.1%	100.0%
	Specificity	78.6%	97.1%	80.0%
	Positive predictive value	55.9%	91.0%	71.4%
	Negative predictive value	77.5%	82.0%	100.0%
W angle	Sensitivity	62.8%	62.8%	100.0%
	Specificity	81.4%	97.1%	84.3%
	Positive predictivevalue	62.8%	97.6%	76.1%
	Negative predictive value	81.4%	81.5%	100.0%
WITS appraisal	Sensitivity	62.8%	100.0%	100.0%
	Specificity	100.0%	81.4%	100.0%
	Positive predictive value	100.0%	72.9%	100.0%
	Negative predictive value	84.3%	100.0%	100.0%

Results:

This study was undertaken to check the validity and predictability of the MKG angle and Tau angle and their correlation with the ANB angle, W angle, Yen angle, Beta angle, and WITS appraisal. Results from this study indicate that a significant difference between MKG angle, Tau angle, ANB angle, W angle, Yen angle, and Beta angle and WITS appraisal was found.

This study reported from Spearman's correlation coefficient that amongst Class I patients, MKG angle and Tau angle had no significant association with ANB angle, BETA angle, Yen angle, W angle, or WITS appraisal. There was statistically significant weak correlation between MKG angle and Tau angle (ρ= -.358, p value<.05).

Amongst Class II patients, Tau angle had no significant association with ANB angle, Beta angle, Yen angle, W angle, WITS appraisal, and MKG angle. MKG angle had statistically significant moderate positive correlation with ANB angle (ρ= .453, p value<.05) and statistically significant moderate negative correlation with Yen angle (ρ= -.509, p value<.05).

Amongst Class III patients, MKG angle had no significant association with ANB angle, Beta angle, Yen angle, W angle, or WITS appraisal. There was statistically significant weak negative correlation between MKG angle and W angle (ρ= -.364, p value<.05) as well as between MKG angle and WITS appraisal (ρ= -.358, p value<.05).

Amongst Class III patients, Tau angle had no significant association with WITS appraisal. There was statistically significant strong negative correlation between Tau angle and ANB angle (ρ= -.771, p value<.05). There was statistically significant strong negative correlation between Tau angle and Beta angle (ρ= -.726, p value<.05). There was statistically significant very strong negative correlation between Tau angle and Yen angle (ρ= -.800, p value<.05). There was statistically significant very strong negative correlation between Tau angle and W angle (ρ= -.838, p value<.05). There was statistically significant moderate positive correlation between Tau angle and MKG angle (ρ= .445, p value<.05).

From table 4, we checked the predictability of parameters and a predictive test was applied, which showed that for Class I, the Tau angle had the highest sensitivity of 100% and specificity of 94.3%, followed by the Beta angle, i.e., 88.6% and 100%.

For Class II, the highest accuracy would be seen in Beta angle, i.e., 100%, followed by Tau angle, i.e., sensitivity of 91.4% and 100% specificity.

For Class III, all the parameters showed the highest accuracy level, from our present data we get to the statement that the Tau angle has the highest accuracy for predicting the sagittal skeletal relation along with ANB and Beta angle. The MKG angle was found to be less predictable, whereas the Tau angle and Beta angle were found to be the most predictable for Class I, Class II, and Class III subjects.

Discussion:

The most commonly used method for assessing the sagittal jaw relationship is the ANB angle, in which the position of the nasion is not fixed during growth. To overcome this, the WITS appraisal was introduced, but it uses the occlusal plane that can be easily affected by tooth eruption and dental development as well as by orthodontic treatment. Later on, the Beta angle was introduced, which avoids the use of the occlusion plane and is not affected by jaw rotations. However, it uses point A and point B, which can be remodelled by orthodontic treatment and growth. Despite its limitations, previous studies found it to be adequate for determining sagittal jaw relationships. Because of these existing problems with beta angle, Yen angle was proposed with the following reference points: S, M, and G. However, it wasn't a stable point [12]. As the W angle uses the same unstable parameters as the Yen angle, it makes the concept of jaw rotation and SG line unclear. Therefore, this angle is not so satisfying and their accuracy is still questionable [12].

Recently introduced angles, the MKG angle and the Tau angle, are used to determine the sagittal jaw relationship. In this study, an attempt was made to find their predictability and their correlation between the widely used variables and a recently proposed cephalometric measurement, which was used to indicate sagittal jaw relationship.

In our present study it was reported that the MKG angle, Tau angle, Beta angle, ANB angle, Yen angle, WITS Appraisal and W angle amongst patients with Class I, II and III malocclusion differed significantly (p value<.05). From the present study, it was found that the median value of MKG angle recorded was 57.00 for class I with an inter-quartile range (IQR) of 52.00–60.00, 61.00 for class II with an IQR of 59.00–64.00, and 40.00 for class III with an IQR of 33.00–48.00. This was in accordance with the result of Chachada et al.[8], where he stated that the mean value for the MKG angle in the class I skeletal pattern group was 54.9º ± 6.2º, whereas the mean values for the classes II and III skeletal pattern groups were 64.3º and 45.1º with a SD of 8.5º each.

For Tau angle, we reported that the median value for class I was 31.00 with an IQR of 30.00–33.00 for class II, 36.00 with an IQR of 35.00–39.00 for class III, and 23.00 with an IQR of 21.00–26.00. That seems to be approachable with the mean values that were reported by Gupta et al.[9]; 31.93 ± 1.69 for class I, 38.32 ± 2.93 for class II, and 25.54 ± 2.86 for class III.

For Yen angle, the median value for class I was 122.00 IQR 120.00–125.00, class II 116.00 with IQR 113.00–118.00, and for class III 141.00 with IQR 137.00–146.00. According to Neela et al. [6], the mean value for Yen Angle in skeletal Class I subjects was 120.5 2.9, compared to 114 3.6 in skeletal Class II subjects, and 129 4.6 in skeletal Class III subjects. Thus, the results of this study were on par with those of the above study.

The median value for Beta angle recorded in the present study for skeletal class I was 30.00 with an IQR of 28.00-33.00, class II was 23.00, with an IQR of 18.00-26.00, and for class III, 43.00, with an IQR of 41.00-48.00. The mean value for Beta angle in skeletal Class I subjects was 31.1 ± 2, for skeletal Class II it was 24.5 ± 3, and for skeletal Class III it was 40.0 ± 4.2 reported by Baik and Ververidou [5]. Thus, the results of this study were in accordance with the above study.

The result for W angle from our present study showed that the median value for class I was 54.00 with an IQR of 53.00-57.00, for class II it was 50.00 with an IQR of 50.00-52.00, and for class III it was 66.00 with an IQR of 64.00-69. According to Bhad et al. [7], the mean value for W Angle in skeletal Class I subjects was 53 ± 2, 48.9 ± 2.1 in skeletal Class II, and 58.7 ± 3.2 in skeletal Class III. Thus, the results of this study were in accordance with the above study for classes I and II, but for class III the result is on par with the previous study.

In the present study, it was found that Tau angle and Beta angle are the most predictable for differentiation of Class I, Class II, and Class III subjects, while MKG angle was found to be less predictable for differentiating sagittal jaw relationships as key ridge, being a bilateral landmark, can result in errors in identification and variability. Thus, further studies are recommended using digitized software packages for the determination of key ridges.

Conclusion:

From the present study, the following conclusions can be stated:

1. The ANB, Tau, and Beta angles were discovered to be the most predictable for Class I, Class II, and Class III, implying that the Tau angle, along with the ANB and Beta angles, can be used to assess the sagittal jaw relationship.
2. In particular, the Tau and Beta angles were found to be the most significant in terms of differentiating between class I and class II samples.
3. The MKG angle was found to be less predictable for differentiating samples.

This report also concluded that all sagittal jaw relationship evaluation parameters are affected by changes in one or another parameter. There is no perfect measurement for all cases. A combination of different measurements should be used for proper evaluation of the sagittal maxillo-mandibular relationship. In this study, ANB, Tau, and Beta angles have been proven to be accurate in differentiation and assessment of sagittal jaw relationship. However, further study with a larger sample size needs to be carried out to assess the sagittal jaw discrepancy.

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