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The Tau Angle, Beta Angle, ANB Angle and Wits Appraisal in Assessing Sagittal Skeletal Relationship- A Cephalometric Study

(The Tau Angle's and its Correlation with other Sagittal Skeletal Parameters)

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Abstract:- The assessment of the sagittal skeletal relationship is critically important in orthodontic diagnosis and treatment planning. The Tau angle is used to assess the sagittal skeletal relationship which relies on stable craniofacial landmarks: points T, G, and M. This present study aims to evaluate the reliability of the Tau angle, Beta angle, ANB angle and Wit's appraisal in assessment of anteroposterior jaw dysplasia thus in future the Tau angle would stand along with other novel sagittal relationship indicators. This study included pretreatment lateral cephalograms of 279 patients, age group 13- 30 years visiting our Department of Orthodontics and Dentofacial Orthopedics of a dental institution. They were grouped into skeletal class I, II and III mal-occlusion depending on Tau angle, Beta angle, ANB angle and Wit's appraisal. One sample t-test used to determine the differences among the three skeletal patterns. In assessing sagittal relationship, skeletal class I malocclusion would have Tau angle 28˚- 34˚, Beta angle 27˚- 35˚, ANB 2=/-2˚, Wit's- AO and BO coinciding in females, BO 1mm ahead of AO in males; Skeletal class II malocclusion would have Tau angle >34˚, Beta less than 27˚, ANB >4˚, Wit's -AO leading BO in females, AO similar to or leading ahead of BO in males; skeletal class III malocclusion would have Tau angle less than 28˚, Beta angle < 35˚, ANB less than 1, Wit's BO ahead of AO in females, BO ahead of AO greater than 1mm. The statistical analysis revealed no significant difference in the mean Tau, Beta, ANB angle and Wit's appraisal values among three groups with those of standard reference values ($p \leq 0.05$).

Keywords:- *Cephalometry, Stable Landmark, Growth Changes, Remodeling.*

I. INTRODUCTION

Diagnosis is the basis of orthodontic treatment planning. In 1934, cephalometric radiograph came into existence by Hofrath in Germany and Broadbent in the United States has been serving as a basis of clinical and research tools for the study of malocclusion and underlying skeletal disproportions [1]. Cephalometric landmarks are locations on a physical structure, or constructed points like an intersection of two planes. These points are subject to changes depending on the patient's head position or during the growth period of an individual, so utmost importance must be thrown into their consistency. The assessment of the sagittal skeletal relationship holds a significant place in diagnosis and treatment planning[2]. The anteroposterior discrepancy can be assessed by numerous analyses which have been described over years with different degrees of reliability. Angle ANB, in Steiner's analysis, is the most popular parameter for evaluating sagittal skeletal relation [3]. Although it is considered invalid, according to the findings of Taylor et al [4,5] in 1969, due to the anteroposterior position of Nasion and the rotational effect of jaw bases. Wit's appraisal, described by Jacobson et al [6] is based on the occlusal plane, points A and B. Other parameters like Beta angle by Baik et al [7], Yen angle by Neela et al [8] also assess anteroposterior sagittal dysplasia. But these may also be subjected to variations during orthodontic tooth movement, growth period, or rotational tendencies. Thus, focusing on the stable landmarks that stands idiosyncratic despite growth changes, orthodontic tooth movements, rotations, and tooth eruptions becomes an essential requirement [9]. Such a sagittal parameter was described by Gupta et al [10], known as the Tau angle. It relies on stable craniofacial landmarks and does not undergo any remodeling during growth, rotations of jaws or tooth movement. This study aims to evaluate the reliability of the Tau angle, Beta angle, ANB angle and Wit's appraisal in assessment of anteroposterior jaw dysplasia in our study population, thus in future the Tau angle would be one among the other novel sagittal relationship indicators. The null hypothesis tested was, that there exists no correlation between the Tau angle, Beta angle, ANB angle and Wit's appraisal.

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II. MATERIALS AND METHODS

It was a retrospective study design, where pretreatment lateral cephalometric radiographs were obtained with patients informed consent. 279 lateral cephalometric radiographs of patients of age 13- 30 years who visited the Department of Orthodontics and Dentofacial Orthopedics from 2022 to 2023 of a dental institution. Ethical clearance was obtained **(IHEC-I/0773/22)**. The sample size calculation was performed using the OpenEpi software version 3.01 with an expected sensitivity and specificity of 95 and 88%, respectively, and a desired precision of 5% at a 95% confidence interval. The sample size was found to be 93. Since the study included three groups, the total sample size was taken as 279.

➢ *Inclusion Criteria:*

- Standardized pretreatment lateral cephalograms
- No history of orthodontic treatment
- Fully erupted permanent dentition

➢ *Exclusion Criteria:*

- Any craniofacial anomalies affecting landmark identification
- Any systemic disease
- Radiographic distortions

➢ *Study Groups Were Classified Based on Predetermined Values into Skeletal Class I, II, and III.*

- **Group I:** Skeletal class I possessing Tau angle 28˚- 34˚, Beta angle 27˚- 35˚, ANB 2=/-2˚, Wit's- AO and BO coinciding in females, BO 1mm leading in front of AO in males
- **Group II:** Skeletal class II possessing Tau angle >34°, Beta angle < 27°, ANB angle > 4°, Wit's - AO front of BO in females and AO coinciding or in front of BO in males
- **Group III:** Skeletal class III possessing Tau angle < 28°, Beta angle > 35°, ANB angle < 1°, Wit's with BO front of AO in females and BO front of AO by >1 mm in males.

All lateral cephalograms were taken with patients positioned in natural head position with Frankfort horizontal plane parallel to the floor. Ear rods stabilized the head, and were placed in the external auditory meatus, and the nosepiece at the bridge of the nose. The X-rays passed perpendicular to the sagittal plane of the patient's head and the distance from the mid-sagittal plane to the tube was kept at 5 feet. 279 lateral head films were subjected to the hand tracing method by a single observer and the tracing were re-traced by two additional observers in a two-week interval for 3 times, in order to eliminate intra- observer and inter-observer reliability. As represented in Fig. 1 to Fig. 4, a total of 8 landmarks involved in 4 parameters were included from the parameters under study. Tracing was done on standardized lateral head films measuring 8 inches * 10 inches using acetate matte tracing paper (0.003 inches thick * 8 inches* 10 inches) and a fine felt-tipped 0.5mm 3H pencil. View box was utilized for manual tracing. The data was collected with the use of a protractor for angular measurements and a millimeter ruler for linear measurements.

➢ *The Measurements were as Follows:*

- Tau angle (τ): Construction of τ angle uses three skeletal reference points, which are point M, point G, and point T. Point T is the uppermost point at the intersection of the tuberculum sellae and the frontal wall of the pituitary fossa. Tau Angle forms between two lines which are drawn connecting the point T to G and the point M to G
- ANB angle: It is the angle formed between the NA and NB line
- Beta angle: It utilizes points A, B and Condylion (Co). Points Co and B are connected through a line and a perpendicular is drawn from point A to the CO-B line. The angle between the AB line and the perpendicular from point A forms the beta angle.
- Wit's appraisal: It is the measured linear distance between AO and BO, where a perpendicular line is drawn from point A on the occlusal plane(O) and from point B to the Occlusal plane(O).

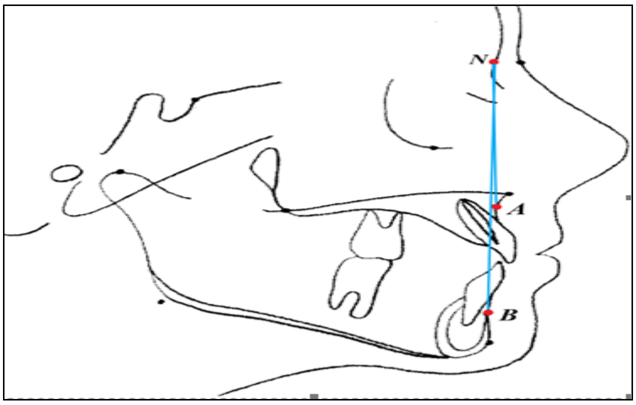

Fig 1: ANB Angle

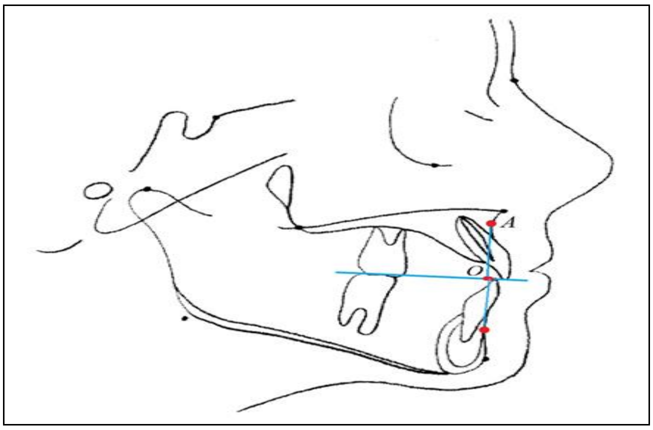

Fig 2: Wit's Appraisal

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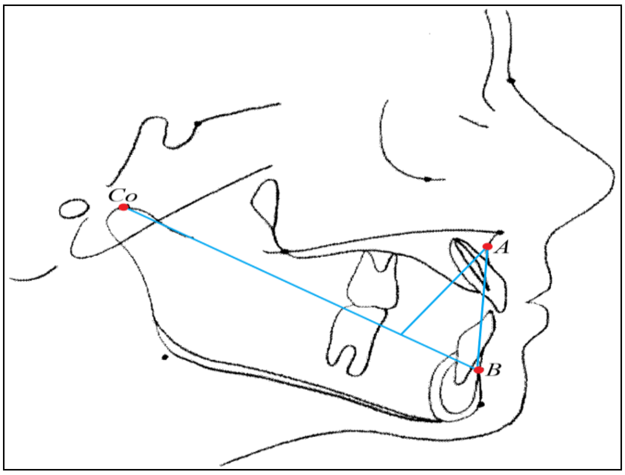

Fig 3: Beta Angle

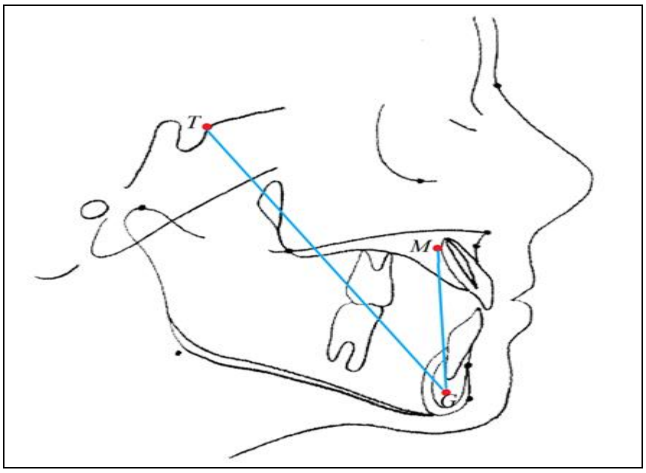

Fig 4: Tau Angle

➤ *Statistical Methods:*

Statistical Package for the Social Sciences (SPSS) was used for data analyzation (version 20) with a confidence level set at 5% (P < .05). Minimum and maximum value, mean and standard deviation was calculated by descriptive analysis. To assess the difference in measured values for all skeletal classes, one sample t-test was done to check the reliability of all performed analyses in assessing the skeletal malocclusion in the sagittal plane.

III. RESULTS

From Table I, we deduce that the skeletal class I population had test values similar to those of our standard reference values and from Tables II and III, it is found that the skeletal class II and III population had test values similar to those of our standard reference values. This infers that the Tau angle abides with ANB and Beta angles in evaluating sagittal skeletal discrepancies. Table IV shows that the study population had similar values corresponding to reference inputs of Wit's appraisal stating that, there is no significant difference in the test values as compared to standard reference values.

Table 1: Comparison of Cephalometric Values with Standard Reference Values in Class I Population

Variable	Standard Reference Value	Test Value of Study Population	P Value
Tau	31.93	30.53	0.056*
Beta	31.0	30.67	0.10
ANB	2.5	2.59	0.26

P value<0.05 is Considered to be Significant

Table 2: Comparison of Cephalometric Values with Standard Reference Values in Class II Population

Variable	Standard Reference Value	Test Value of Study Population	P Value
Tau	38.32	36.94	0.057*
Beta	<27	23.89	0.72
ANB	>4	6.09	0.49

P value<0.05 is considered to be significant

Table 3: Comparison of Cephalometric Values with Standard Reference Values in Class III Population

Variable	Standard Reference Value	Test Value of Study Population	P Value
Tau	25.54	25.25	0.053*
Beta	>35	38.82	0.054*
ANB	<1	-1.94	0.86

P value<0.05 is considered to be significant
Test: One sample t test

The tests in each of the Class shows that there is no significant difference in the Cephalometric values as compared to standard reference values

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Table 4: Results in Wit's Appraisal

Skeletal Class	Wit's Analysis Result	N	%
I	Coincident	131	100.0
II	AO ahead of BO	116	100.0
III	BO ahead of AO	35	100.0

100% of the cases in the study population comply with the reference values/results in Wit's analysis

IV. DISCUSSION

Cephalometric parameters accurately determine various anteroposterior relations in jaws by taking reference to standard skeletal landmarks. The reproducibility of a landmark should be considered while assessing its reliability [11, 12]. Numerous parameters that have been evaluated previously are subjected to changes during orthodontic tooth movement [13], growth changes [14] and lower reproducibility of landmarks [15].

The findings of our study convey that in Group I, Tau angle values felt within Tau angle 28°- 34° for the skeletal class I population. This was coinciding with the skeletal class I values for ANB, Beta angle, and Wit's appraisal. For Group II which included the skeletal class II population, the Tau angle was greater than 34°, and ANB, Beta angle and Wit's appraisal followed standard reference values. Similarly for Group III, which was the skeletal class III population, values for the Tau angle were lesser than 28° and other parameters coincided with their reference values.

The Tau angle values obtained by our study were approachable with the mean values that were reported by Gupta et al (2020); 31.93 ± 1.69 for class I, 38.32 ± 2.93 for class II, and 25.54 ± 2.86 for class III. Our findings were compatible with the findings of Kaushik et al (2022) which assessed the diagnostic validity of MKG and the Tau angle with ANB, Wit's appraisal, Beta angle, Yen angle, and W angle.

ANB angle, the most popular parameter in assessing the sagittal relationship, is affected by growth changes in N point, and points A and B change during orthodontic tooth movement (Taylor et al). Beta angle (Baik et al), based on Points A, B which are subjected to alterations in orthodontic tooth movement and Condylion point Co, representing the apparent axis of condyles is subjected to lower reproducibility and intra examiner variations. Localization of Co was described to be difficult due to magnification differences inherent in bilateral structures and resulting image distortion [16, 17, 18]. Wit's appraisal by Jacobson et al, is based on the Occlusal plane, which is a dental parameter which that may be subjected to changes associated with missing teeth, eruption [19], etc. and is not a reliable landmark in assessing the sagittal skeletal relationship.

The Tau angle [10] is considered to be a stable parameter, as points G, M, and T do not undergo any changes during growth and also in rotations of jaw and tooth movements. Point T represents the uppermost point at the junction of the frontal wall of the pituitary fossa and tuberculum sellae. Point G is the focal point of the biggest circle that is tangent to the inner frontal, posterior and lower edge of the mandibular symphysis. Point M is the center of the biggest circle that is tangent to the frontal, upper and palatal surfaces of the maxilla. Longitudinal growth studies involving metallic skeletal markers have revealed that few cranial base structures remain stable after reaching a certain age. Point T, according to Melsen et al [14], does not undergo remodeling changes after 4- 5 years. Studies done with metallic skeletal marker by Bjork also indicate that few skeletal landmarks attain stability at a certain period of age [20]. Points G and M do not vary like points A and B, during the growth of jaws or orthodontic movement of teeth as they remain close to the centroid of the maxilla and mandible [21]. Moreover, a centroid is the most stable point of an area or volume [22].

In assessing sagittal dysplasia, rotational jaw movements may mask the underlying skeletal discrepancies if points like A and B are considered [23]. Tau angle was found to be stable even during the rotational jaw tendencies as both the lines forming the Tau angle move in the same direction during clockwise or counterclockwise rotations. These findings depict that the Tau angle would fall in queue as one of a novel indicator in the assessment of sagittal dysplasia among other parameters.

V. LIMITATIONS IN THE STUDY

- Despite its numerous advantages, one of the limitations of the Tau angle is that it failed to describe which jaw base has a sagittal discrepancy.
- Manual tracing method was implemented, which could attract errors, despite observing inter and intra-observer reliability.
- Further, the study should be extended, along with other sagittal parameters, with respect to growth and treatment changes on a broader clinical trials and longitudinal studies in a wide population to reveal its significance and to encompass its reliability.

VI. CONCLUSION

Our study infers that a strong correlation exists between Tau, Beta, ANB angle and Wit's appraisal, the Null hypothesis thus being rejected. Therefore, Tau angle would be one among the novel parameter for assessing the sagittal skeletal relationship. To conclude,

- The Skeletal class I cases, would have Tau angle between 28 to 34 degrees
- The Skeletal class II cases would have Tau angle greater than 34 degrees

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- The Skeletal class III cases would possess Tau angle values lesser than 24 degrees.
- **Conflict of Interest:** None.
- **Fundings Involved for the Study:** None.

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