ORIGINAL ARTICLE

Tau Angle: A New Approach for Assessment of True Sagittal Maxillomandibular Relationship

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Abstract

Aim: The orthodontic treatment planning relies on correct diagnosis of skeletal discrepancy, which demands accurate and precise cephalometric parameters. This study proposed an angle, which is based on unvarying cephalometric points and gives a true sagittal skeletal maxillomandibular relationship.

Materials and methods: The present study was conducted on 279 individuals (13–30 years), which were divided into three groups (class I, II, and III skeletal malocclusion) depending on beta, wits, and ANB (A point, Nasion, B point) angles. Tau angle was measured, which lied at the junction of lines connecting the points T to G and G to M. ANOVA and the Dunnett T3 *post hoc* test were used to discern difference between three skeletal patterns. The gender difference in each skeletal pattern was found using the unpaired Student's *t*-test. Receiver-operating characteristic (ROC) curves determined the Tau angle's sensitivity and specificity to differentiate among skeletal patterns.

Results: The Tau angle between 28° and 34° suggests a skeletal class I malocclusion; values below 28° show a class III skeletal pattern and above 34° suggest skeletal class II pattern.

Conclusion: Tau angle gives a true sagittal skeletal relationship, which depends on stable landmarks and is unaffected by rotation of jaws in vertical dimension due to growth or orthodontic therapy.

Clinical significance: Tau angle provides a demarcation among three skeletal malocclusions, which can be an important tool for treatment planning in pediatric patients having both anteroposterior and vertical dentofacial discrepancies.

Keywords: ANB angle, Beta angle, Cephalometric landmark, Wits analysis.

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Introduction

The essence of orthodontic treatment planning and final esthetic outcome lies in the precise estimation of dentofacial discrepancy. Lateral cephalogram is an indispensable component of determining the maxillomandibular discordance in sagittal dimension. The ANB angle[1] is the most popular cephalometric parameter to ascertain apical base jaw discrepancy but it is affected by growth and orthodontic therapy-induced rotation of the jaws.[2] Further, variance in the cranial base length also influences ANB angle.[2] It has also been observed in previous studies that position of the nasion changes with growth, thereby influencing ANB angle.[3–6]

Wits appraisal,[2] beta angle,[7] and recently W angle[8] were proposed to overcome the limitations of the angles that preceded them. Wits appraisal assesses the skeletal relationships based on the occlusal plane, which is a dental parameter. Precise ascertainment of the occlusal plane is demanding and difficult to reproduce particularly during transitional phases of dental development, missing teeth, malocclusions, jaw deformities, etc.[9,10] The occlusal plane also changes with tooth eruption and by orthodontic treatment.[11,12]

Beta angle uses point A as the landmark similar to other previous angles to determine sagittal discrepancy. The position of point A changes with orthodontic tooth movement-induced alveolar bone remodeling.[13–15] The position of condyle is also difficult to locate and reproduce, which influences the reliability of beta angle.[16–18] Although W angle uses M and G points as reference landmarks that are quite stable and unaffected by local remodeling owing to movements of the teeth,[19,20] the S point is unstable and highly variable as it displaces backward and downward during growth.[21–23]

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Specific Objective

Tau (τ) is a Greek alphabet that is used as a time constant in physical sciences and was denoted as a symbol for resurrection. The present study was aimed to introduce a novel angle, which was hence named Tau angle as it depends on stable bony landmarks and precisely estimates the true sagittal skeletal relationship of the maxilla and mandible irrespective of change in vertical dimension.

Tau Angle

The Tau angle is a novel parameter to determine the true bony sagittal maxillomandibular relationship (Fig. 1). The Tau angle is constructed by marking three cephalometric landmarks:

Point T: Uppermost point at the junction of the frontal wall of pituitary fossa and tuberculum sellae;

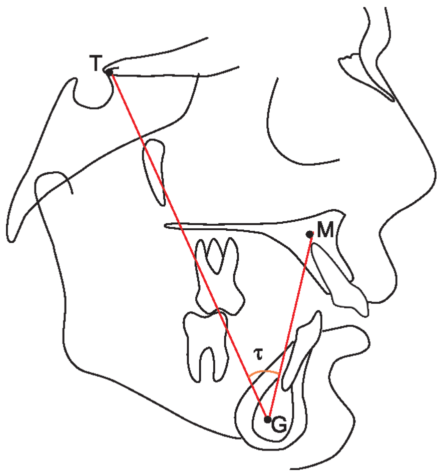


Fig. 1: Tau (τ) angle

Point M: Constructed point representing the center of the biggest circle that is tangent to the frontal, upper, and palatal surfaces of the maxilla;
Point G: Focal point of the biggest circle that is tangent to the inner frontal, posterior, and lower edge of the mandibular symphysis.

Tau angle lies between the two lines connecting T and G points and M and G points.

The objective of the current study was establishing the Tau angle's mean and standard deviation for three skeletal malocclusions.

Materials and Methods

Study Design

A cross-sectional study.

Participants, Eligibility Criteria, and Settings

The study comprised of pretreatment records of subjects who reported to the orthodontic department of our institute. Patients were included based on following criteria:

- Standardized lateral cephalograms
- Erupted permanent dentition till second molar
- Absence of craniofacial anomalies
- No history of any systemic disease

Sample Size Calculation

The sample size was calculated using expected sensitivity and specificity of 95 and 88%, respectively, with desired precision of 5% at 95% confidence interval. The calculation was performed using the OpenEpi software version 3.01 and the sample size was found to be 93. Since we have three groups, so the total sample size was taken as 279.

Data Segregation

Subjects were divided into three groups (class I, II, and III skeletal malocclusions) based on pretreatment cephalometric readings of beta angle and either wits or ANB angle.

- Class I = Beta angle of 27–35°, ANB angle of 1–4°, and/or wits appraisal with AO and BO coinciding in females and BO front of AO by 1 mm in males.
- Class II = Beta angle < 27°, ANB angle > 4°, and/or wits with AO front of BO in females and AO coinciding or front of BO in males.
- Class III = Beta angle > 35°, ANB angle < 1°, and/or wits with BO front of AO in females and BO front of AO by >1 mm in males.

Of the 325 patients initially selected, we chose 279 records that met the inclusion criteria and were in the age group of 13–30 years.

Class I included 101 patients (51 males, 50 females).

Class II consisted of 101 patients (51 males, 50 females).

Class III comprised of 77 patients (37 males, 40 females).

Cephalometric Analysis and Reliability

All the cephalograms were traced by two investigators (NS and PG) independently and cephalometric readings (Tau, beta, wits, and ANB angles) were measured for interobserver agreement.

Statistical Analysis

The statistical analysis was done using the SPSS software version 23.0 (SPSS Inc., Chicago, IL). $p \leq 0.05$ was set as the significance level. The intraclass correlation coefficient was calculated for cephalometric measurements to determine interexaminer reliability. The normality of the data was assessed by skewness, kurtosis, and Shapiro-Wilks W tests, which were found to be parametric. Figure 2 shows histogram and normal Q-Q plot depicting normal distribution. ANOVA and Dunnett T3 post-hoc test determine differences among three skeletal patterns. The unpaired Student's *t*-test was employed for finding the significant difference between the genders in each skeletal pattern. Receiver operating characteristics curves were used for determining the Tau angle's sensitivity and specificity to differentiate among three different skeletal patterns.

Results

The intraclass correlation coefficient for interobserver agreement was found to be 0.998–1.000.

Table 1 shows the descriptive statistics for Tau angle in three skeletal patterns. The mean and standard deviation for Tau angles in the class I, II, and III groups were 31.93 (±1.68)°, 38.32 (±2.93)°, and 25.54 (±2.85)°, respectively.

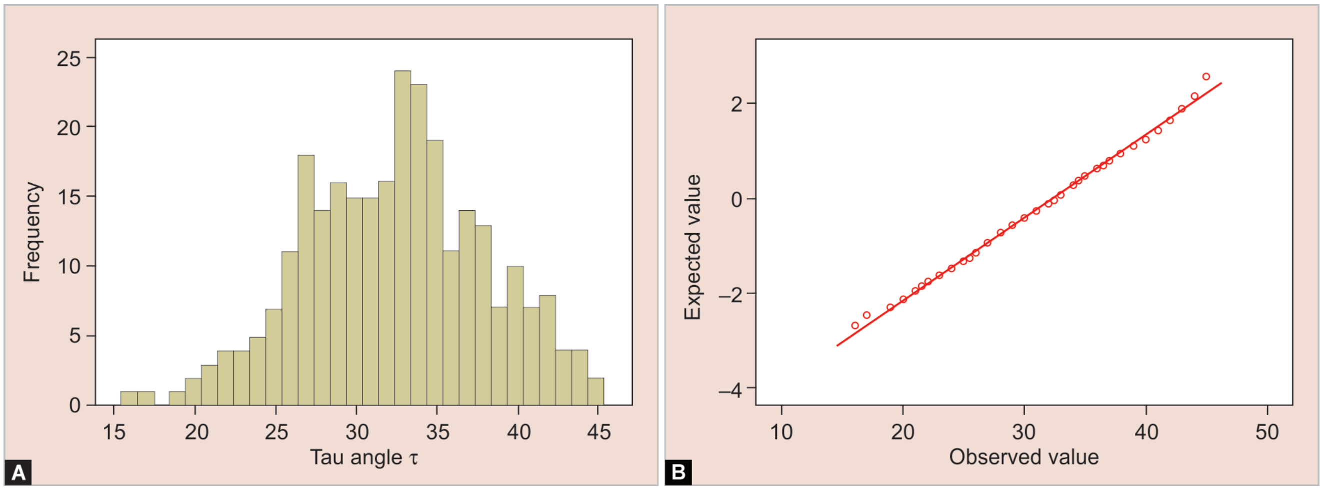
The ANOVA and Dunnett T3 test revealed significant difference in the mean Tau angle values among three groups ($p \leq 0.05$) (Table 1). *t* tests conveyed no significant difference in Tau angle values between genders in each skeletal pattern.

Receiver operating characteristic curves demonstrated that a Tau angle <28.5° is 100% sensitive and 92% specific in differentiating class III from class I. A Tau angle >34.25° is 96% sensitive and 98% specific in differentiating class II and I. Thus, ROC curves set forth the Tau angle cutoff points of class III and II skeletal patterns with class I to be approximately 28.5° and 34.25°, respectively. The former values coincide with the mean of class I skeletal pattern (31.87 ± 1.64°).

Hence, it can be estimated with a high validity that the Tau angle between 28.5° and 34.25° would truly represent a skeletal class I malocclusion. The results also demonstrated that patients with Tau angle < 28.5° has a class III, and greater than 34.25° has a skeletal class II malocclusion.

Discussion

Cephalometric parameters that are employed for precise and accurate assessment of true sagittal relationships depend on stable, reliable, and reproducible landmarks. Parameters based on unstable landmarks will result into fallacious diagnosis, treatment



Figs 2A and B: (A) Histogram; (B) Normal Q–Q plot showing the distribution of Tau angle in the sample depicting normal distribution

Table 1: Descriptive statistics for the sample with mean values of Tau angle in three classes of malocclusion and Dunnett T3 testing for comparison among group means

					Dunnett T3		
Malocclusion (a)		*N*	*Age*	*Mean ± SD*	*Malocclusion (b)*	*Mean difference (a − b)*	*Significance*
Class I	Total	101	17.49 ± 4.32	31.93 ± 1.69	Class II	−6.38	0.000*
	Male	51			Class III	6.39	0.000*
	Female	50					
Class II	Total	101	15.55 ± 4.16	38.32 ± 2.93	Class I	6.38	0.000*
	Male	51			Class III	12.77	0.000*
	Female	50					
Class III	Total	77	15.68 ± 4.14	25.54 ± 2.86	Class I	−6.39	0.000*
	Male	37			Class II	−12.77	0.000*
	Female	40					

*The mean difference is significant at the 0.05 level

planning, and assessment of treatment progression. Presently, the cephalometric variables, which determine anteroposterior maxillomandibular relationship are constituted by one or more varying points, which change with growth and orthodontic treatment. Reliability is also an essential factor that defines a parameter in terms of its reproducibility. If a measurement cannot be reproduced consistently, then its value is questionable in terms of cost, time, and patient treatment decisions. Various previous angles have used points with lower reproducibility like point B and condylion (Co), which reduces authenticity of these parameters.[24] Moreover, localization of Co is difficult due to differential magnification inherent in bilateral structures and resulting image distortion.[25] Several researchers have shown that Co cannot be accurately and consistently located on the closed-mouth lateral cephalogram.[26]

Hence, Tau angle has been proposed, which is based on three cephalometric landmarks: points T, G, and M. The T point is one of the most clearly defined structure and stable (100%) landmarks located in the middle cranial base of the skull.[27] Longitudinal growth studies involving metallic skeletal markers have revealed that some cranial base structures attain stability after reaching a certain age.[21] According to Melsen, T point does not undergo any remodeling after the age of 4–5 years.[23]

Points M and G in maxilla and mandible were established to be superior over cephalometric points A and B as they do not vary by remodeling resulting from growth or movements of the teeth.[19,20] Points M and G approximate the centroid within the maxillary bone and the symphysis. The centroid is the mean point of a structure, which is least liable to vary as compared to other structural points.[28] Moreover, there is strong statistical evidence in favor of the fact that centroid is the most stable point of an area or volume, which is changing in shape.[29]

A valid cephalometric parameter quantifying maxillomandibular relationship must not be influenced by the rotation of the jaws due to any cause in other planes. Mandibular rotation in vertical direction masks the true relationship of the maxilla and mandible sagittally. The new cephalometric parameter Tau angle accurately predicts the true anteroposterior skeletal maxillomandibular relationship. This is due to simultaneous movement of both lines TG and GM constituting the angle in the same direction during rotation of the jaws as shown in Figure 3. Thus, Tau angle gives true sagittal picture with clockwise or counterclockwise jaw rotation.

The Tau angle provides an apparent demarcation among true skeletal class I, II, and III malocclusions, which can be an important tool for treatment planning in patients having both anteroposterior and vertical maxillomandibular discrepancies. Although Tau angle provides true sagittal relationship between the two jaws, yet it requires the assistance of other cephalometric measurements to discern which jaw is at fault. Furthermore, this angle's validity should be explored in different ethnic populations followed

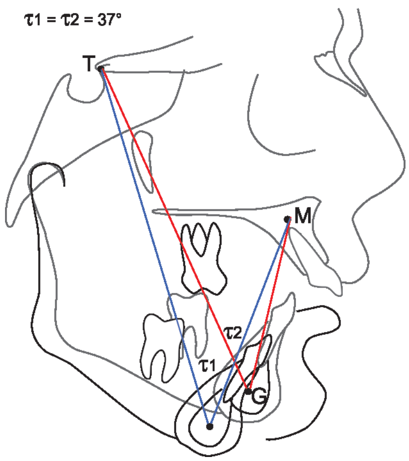


Fig. 3: Tau (τ) angle remains stable with jaw rotation

by establishment of the norms so that it will have a universal application.

Conclusion

- Tau angles between 28° and 34° approx., <28°, and >34° approx. suggest skeletal class I, III, and II malocclusions, respectively.
- No gender difference in Tau angle was observed for different skeletal malocclusions.

Thus, Tau is a novel angle that depends on all stable landmarks giving a true sagittal skeletal picture of jaws.

Clinical Significance

Tau angle aids in diagnosis of true jaw discrepancy in sagittal dimension, thereby assisting in utilization of growth potential in children through implementation of precise therapeutic intervention.

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