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ASSESSMENT OF THE SAGITTAL JAW DISPROPORTION USING NEW TAU ANGLE ANALYSIS

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Abstract

Background. Accurate assessment of sagittal jaw relationships is fundamental to orthodontic diagnosis and treatment planning; however, no single cephalometric parameter fully describes skeletal jaw disproportion. Although the ANB angle remains widely used, its interpretation may be affected by growth, jaw rotation, and anatomical variations. This study investigated the relationship between the conventional ANB angle and the novel Tau angle in assessing sagittal jaw disproportion among Filipino patients with skeletal Class I, II, and III malocclusions.

Methods. This descriptive-correlational study included 80 lateral cephalometric radiographs of Filipino male and female patients with skeletal Class I, II, and III malocclusions obtained from a dental clinic in Quezon City, Philippines. Each radiograph was analyzed using the ANB and Tau angles. ANB-based skeletal classifications followed established Filipino cephalometric norms: Class I, 1.5°–5.5°; Class II, ≥6°; and Class III, <1.5°. For the Tau angle, Asian normative values were applied: Class I, 28°–34°; Class II, >34°; and Class III, <28°. Landmark identification, tracing, and interpretation were independently validated by three certified orthodontists. Differences according to age and sex were assessed, and the relationship between the two analyses was evaluated using Kendall's Tau-b correlation.

Results. No significant differences in skeletal classification were observed across age groups or between sexes using either the ANB or Tau angle. A strong positive correlation was found between the ANB and Tau angle analyses (Kendall's Tau-b = 0.79, $p < 0.01$), indicating substantial agreement between the two methods.

Conclusion. The Tau angle demonstrated substantial agreement with the conventional ANB angle in classifying sagittal jaw relationships and may serve as an alternative when ANB landmarks are difficult to

identify. Further studies are recommended to establish population-specific normative Tau angle values for Filipino patients.

Keywords: *ANB angle, Cephalometric analysis, Orthodontic diagnosis, Sagittal jaw disproportion, Skeletal malocclusion, Tau angle*

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Research Highlights

What is the current knowledge?

- The ANB angle remains the gold standard for assessing sagittal skeletal jaw relationships but is influenced by growth, jaw rotation, dentoalveolar remodeling, and craniofacial variations.
- The Tau angle, introduced in 2020, uses stable craniofacial landmarks that are less affected by vertical changes and jaw rotation, making it a promising alternative for sagittal jaw assessment.
- Previous studies have shown that although the Tau angle can classify skeletal malocclusions comparably to the ANB angle, its reliability and repeatability require further validation.
- Limited evidence exists regarding the clinical performance of the Tau angle, particularly among Filipino populations, highlighting the need for additional validation studies.

What is new in this study?

- This study provides new evidence on the relationship between the novel Tau angle and conventional ANB angle in assessing sagittal jaw disproportion among Filipino individuals with skeletal Class I, II, and III malocclusions.
- It is among the first studies to evaluate the clinical reliability of the Tau angle analysis in a Filipino population, addressing the need for population-specific validation.
- The study demonstrates that the Tau angle has comparable reliability to the ANB angle, with a strong positive correlation between the two analyses (Kendall's Tau-b = 0.79, $p < 0.01$).
- The findings establish that age and sex do not significantly influence sagittal jaw classification using either analysis, supporting the broader applicability of the Tau angle.
- This research highlights the potential use of the Tau angle as an alternative cephalometric parameter when ANB landmarks are obscured or difficult to identify, with implications for orthodontic diagnosis and future digital/AI-based cephalometric analysis.

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INTRODUCTION

Sagittal jaw disproportion is characterized by the anteroposterior discrepancy between the maxilla and mandible and represents one of the fundamental components in the diagnosis of skeletal malocclusion. The identification and accurate assessment of sagittal maxillomandibular relationships are essential in orthodontics because these relationships influence treatment planning, growth modification strategies, orthodontic camouflage, orthognathic surgical decisions, and evaluation of treatment outcomes. Skeletal discrepancies are commonly classified into Class I, Class II, and Class III patterns according to the relative position of the maxilla and mandible, providing clinicians with essential information regarding the underlying skeletal component of malocclusion (Proffit et al., 2019; Al-Gumaei et al., 2022). Therefore, reliable cephalometric assessment remains an important component of comprehensive orthodontic diagnosis.

Over the years, numerous cephalometric analyses have been introduced to evaluate sagittal jaw relationships and improve diagnostic accuracy. Among these methods, the ANB Angle has remained the most widely accepted and frequently used measurement for assessing sagittal maxillomandibular discrepancy because of its simplicity, accessibility, and clinical applicability. The ANB Angle evaluates the relationship between the maxillary point A, Nasion, and mandibular point B, allowing clinicians to classify skeletal relationships based on established angular values. However, several studies have questioned the reliability of ANB Angle interpretation because the measurement is influenced by factors beyond the actual anteroposterior relationship of the jaws. Variations in cranial base morphology, Nasion position, vertical skeletal growth patterns, mandibular rotation, and changes in the position of points A and B may alter the resulting angle and affect skeletal classification (Jedlinski et al., 2020; Kotula et al., 2023; Shrestha, 2022). Additionally, orthodontic treatment-related dentoalveolar remodeling may contribute to positional changes of cephalometric landmarks, further affecting the accuracy of skeletal assessment (Kalina & Zadurska, 2022).

Because of these limitations, researchers have continued to investigate alternative cephalometric measurements that may provide a more stable and reproducible evaluation of sagittal jaw relationships. Various alternative analyses, including the Wits appraisal, Beta angle, and MKG angle, have been proposed to reduce the influence of cranial base variation and improve sagittal assessment (Bilal et al., 2022; Chachada et al., 2020; Thakur et al., 2021). However, each method has demonstrated certain limitations, emphasizing the continuing need for a measurement based on stable anatomical references that accurately reflects true maxillomandibular relationships.

In this continuously evolving field of orthodontic diagnosis, Gupta et al. (2020) introduced the Tau Angle as a novel cephalometric measurement designed to evaluate sagittal jaw discrepancy using stable anthropometric landmarks. Unlike conventional analyses that rely on landmarks susceptible to positional changes, the Tau Angle utilizes reference points that are proposed to be less affected by growth-related changes, mandibular rotation, and orthodontic tooth movement. The development of this measurement aimed to provide a more consistent assessment of sagittal skeletal relationships and potentially overcome some of the limitations associated with conventional cephalometric parameters.

The diagnostic potential of the Tau Angle has been investigated in subsequent studies. Kotula et al. (2022), through a systematic review evaluating the accuracy and reliability of newly proposed anthropometric landmarks, reported that Tau landmarks demonstrated promising precision compared with routinely used sagittal measurements. The authors suggested that these landmarks may provide a more stable skeletal reference because they exhibit similar positional changes during mandibular rotation. During clockwise or counterclockwise mandibular rotation, the Tau landmarks reportedly move in a comparable direction, potentially reducing the influence of vertical skeletal changes on sagittal evaluation. These findings suggest that the Tau Angle may provide a more stable assessment of sagittal jaw relationships compared with measurements affected by rotational changes.

Furthermore, Kaushik et al. (2023) investigated the correlation between the Tau Angle and established sagittal discrepancy measurements, including the ANB Angle. Their findings demonstrated a significant association between the two analyses and showed that the Tau Angle was capable of differentiating skeletal Class I, Class II, and Class III patterns. The study suggested that Tau Angle analysis may have comparable diagnostic accuracy to the ANB Angle and may serve as a useful alternative measurement for sagittal skeletal classification.

Despite these promising findings, the reliability and clinical applicability of the Tau Angle remain uncertain. In a recent investigation, Kotula et al. (2023) compared the reliability and repeatability of Tau Angle measurements with the ANB Angle. The study reported that measurement error for the Tau Angle was greater than that observed for the ANB Angle, with variability potentially related to the smaller dispersion of horizontal coordinates of landmarks contributing to angular construction. Nevertheless, the authors emphasized that despite differences in measurement error, both analyses demonstrated comparable ability to classify patients into skeletal Class I, Class II, and Class III categories. These conflicting findings highlight the need for additional validation studies to determine whether the Tau Angle can provide consistent and clinically meaningful information.

Although the ANB Angle remains the conventional standard for evaluating sagittal skeletal relationships, its susceptibility to cranial base morphology, mandibular rotation, growth changes, and landmark displacement has encouraged the exploration of alternative methods. The Tau Angle represents a promising approach because of its reliance on relatively stable anthropometric landmarks; however, evidence regarding its reliability, reproducibility, and diagnostic performance remains limited, particularly among different ethnic populations. Since craniofacial morphology varies among populations, validation of the Tau Angle among Filipino patients is necessary before its routine application in clinical practice.

Establishing the reliability of the Tau Angle may contribute to improving orthodontic diagnosis by providing an additional measurement that may reduce the influence of growth-related changes, mandibular rotation, and treatment-related alterations on sagittal assessment (Mittal et al., 2020). A dependable alternative cephalometric analysis may support clinical decision-making, orthodontic education, digital cephalometric assessment, and future artificial intelligence-assisted diagnostic systems. Therefore, further investigation is warranted to determine whether the Tau Angle may serve as a reliable complement or alternative to the conventional ANB Angle.

This study aims to determine the relationship between the ANB Angle and the Tau Angle analyses in assessing sagittal jaw disproportion among selected Filipino patients from a dental clinic in Quezon City, Philippines. Specifically, this study aims to evaluate sagittal skeletal relationships using both cephalometric measurements, determine the distribution of skeletal Class I, Class II, and Class III patterns, assess whether differences exist according to age and sex, and determine the correlation between ANB Angle and Tau Angle classifications in evaluating sagittal maxillomandibular discrepancies.

LITERATURE REVIEW

Evolution of Cephalometric Analysis in Orthodontics

Cephalometric analysis has become an indispensable component of orthodontic diagnosis, particularly in evaluating skeletal and dental relationships that contribute to malocclusion. Since the introduction of lateral cephalometry by Hofrath and Broadbent in 1934, cephalometric techniques have provided clinicians and researchers with standardized methods for assessing craniofacial structures, monitoring growth changes, and guiding treatment planning (Helal et al., 2022). Initially, cephalometric analyses were developed based on the assumption that specific anatomical landmarks could reliably represent the relationship between the maxilla and mandible. Among the earliest approaches, Downs' analysis and Riedel's introduction of the ANB angle established fundamental principles for evaluating sagittal jaw discrepancies. However, as knowledge regarding craniofacial growth and remodeling has advanced, concerns have emerged regarding the reliability of these measurements because of the influence of landmark instability, growth-related changes, cranial base morphology, and rotational effects of the jaws (Gupta et al., 2021; Daokar & Rajput, 2018).

Consequently, the development of cephalometric analysis has been characterized by a continuous search for more stable and reproducible methods of assessing sagittal maxillomandibular relationships. Several alternative approaches, including Wits appraisal, APDI, Beta angle, Yen angle, SAR angle, and MKG angle, have been introduced to overcome limitations associated with conventional measurements. Although these methods have contributed valuable perspectives to sagittal assessment, each has remained associated with specific limitations related to reference plane orientation, landmark identification, and susceptibility to individual craniofacial variation (Bilal et al., 2022; Devanna et al., 2021; Kotula et al., 2022; Chachada et al., 2020). Therefore, the evolution of cephalometric diagnosis reflects not only the development of new measurements but also the ongoing effort to identify anatomical references that more accurately represent true skeletal relationships.

Biological Basis of Sagittal Jaw Discrepancies

In this context, understanding the biological basis of sagittal jaw discrepancy is essential because maxillomandibular relationships are influenced by complex interactions among cranial growth, genetic factors, environmental influences, and functional adaptations. Lateral cephalometric investigations have demonstrated that cranial base morphology plays an important role in determining facial growth patterns by influencing the position and orientation of the maxilla and mandible (Yan et al., 2022). Variations in cranial base length and flexure have been associated with different skeletal patterns. Class II malocclusion has commonly been linked to mandibular retrusion, reduced cranial base dimensions, and altered cranial base angles, whereas Class III malocclusion has frequently been associated with maxillary deficiency, mandibular excess, and changes in cranial base flexure (Alhazmi et al., 2022; Rai et al., 2023; Li et al., 2024). Furthermore, the spheno-occipital synchondrosis has been identified as an important growth center that influences cranial base development and subsequently affects facial growth, jaw positioning, and occlusal relationships (Yang et al., 2019; Al-Gumaei et al., 2022).

Beyond skeletal development, sagittal jaw discrepancies are also influenced by genetic predisposition and environmental factors. Genetic variations affecting craniofacial growth, combined with environmental factors such as mouth breathing, abnormal oral habits, and altered orofacial muscle activity, may contribute to variations in maxillary and mandibular development (Kahn et al., 2020; Zere et al., 2018). These multifactorial influences highlight the importance of accurate skeletal assessment because distinguishing true skeletal discrepancies from dental compensation is critical for appropriate orthodontic diagnosis and treatment planning. Although clinical examination, facial analysis, and soft tissue evaluation provide important diagnostic information, their interpretation may be affected by individual facial characteristics and examiner subjectivity. Similarly, alternative assessments such as dentoskeletal overjet, soft tissue A′–B′ measurements, mandibular symphysis morphology, and facial profile analysis have demonstrated usefulness but remain limited by dentoalveolar compensation and variability in soft tissue expression (Dubey et al., 2021; Ralte et al., 2022; Maspero et al., 2023; Schwabe & Caldwell, 2022).

Despite these limitations, lateral cephalometric analysis continues to serve as a cornerstone of orthodontic diagnosis because of its ability to provide quantitative evaluation of skeletal structures using reproducible anatomical landmarks. Various visual and analytical approaches, such as the Standard Mesh Diagram, have attempted to enhance the interpretation of facial discrepancies by comparing patients with established facial norms. However, these approaches still depend on accurate landmark identification and may not fully resolve the challenges associated with determining the severity of sagittal skeletal discrepancies (Esporlas, 2018). Thus, the need for more reliable and biologically stable landmarks remains a central concern in contemporary orthodontic research.

Limitations of Conventional Cephalometric Parameters

Among conventional cephalometric measurements, the ANB angle remains the most widely accepted and frequently utilized method for evaluating sagittal maxillomandibular relationships. By relating Nasion (N), Point A, and Point B, the ANB angle provides a simple numerical representation of the anteroposterior relationship between the maxilla and mandible and has demonstrated clinical value in differentiating skeletal Class I, Class II, and Class III patterns (Hlongwa, 2019; Bhullar et al., 2020). Numerous investigations have supported its diagnostic usefulness and have shown favorable agreement with other sagittal indicators, including Wits appraisal, Beta angle, and Downs angle of convexity (Ahmed et al., 2018). Traditionally, ANB values of approximately 2° indicate a skeletal Class I relationship, increased values suggest a Class II discrepancy, and reduced or negative values indicate Class III patterns (Ghodasra & Brizuela, 2023).

Nevertheless, although the ANB angle remains the clinical reference standard, its accuracy is influenced by several anatomical and developmental factors. Because the measurement depends heavily on Nasion as a cranial reference point, variations in cranial base length, growth-related displacement, and facial rotation may alter ANB interpretation. Furthermore, Point A and Point B may not always represent true basal bone positions because they may undergo remodeling associated with growth, orthodontic tooth movement, and dentoalveolar compensation (Taylor, 1975; Kumar et al., 2019; Jedlinski et al., 2020; Mittal et al., 2020). These limitations have stimulated the development of alternative measurements based on more stable skeletal references. Although newer indicators such as the Beta angle, Yen angle, and W angle have demonstrated potential advantages, none has consistently demonstrated superiority over the ANB angle across different skeletal classifications and populations (Ali et al., 2018; Bhat et al., 2022).

Emergence of Stable Anatomical Landmarks: The Tau Angle

Building upon this need for improved diagnostic reliability, Gupta et al. (2020) introduced the Tau angle as a novel anthropometric measurement designed to assess the true sagittal relationship between the maxilla and mandible using more stable skeletal landmarks. Unlike conventional measurements that rely on Nasion, Point A, and Point B, the Tau angle utilizes Point T, Point M, and Point G. Point T is located at the junction of the anterior wall of the sella turcica and tuberculum sellae. Point T is notably recognized as one of the most clearly defined structures and stable (100%) landmarks within the middle cranial base of the skull. Anterior Cranial base superimposition on primary and secondary cephalomeric landmarks (Melsen (2009) Bjork (2009) cited in the study of Graf et al., 2022 and Kravitz and Miller 2020) (Figure 4). Point M represents the geometric center of the premaxilla, and Point G represents the centroid of the mandibular symphysis. The angle formed between the TG and GM reference lines is proposed to reflect the true sagittal relationship of the jaws while minimizing the influence of vertical mandibular rotation because both reference lines respond similarly to clockwise and counterclockwise jaw movements (Gupta et al., 2020).

The theoretical advantage of the Tau angle is primarily based on the stability of its selected landmarks. Previous growth studies have demonstrated that structures within the anterior cranial base exhibit relative stability after early childhood, supporting the use of Point T as a reliable reference (Kravitz & Miller, 2020; Graf et al., 2022). However, anatomical variations of the sella turcica, including bridging, irregular morphology, and altered contours, may affect Point T identification and should be considered during interpretation (Gokce & Yavan, 2022; Isranni et al., 2023). Similarly, the use of Point M and Point G aims to reduce the limitations associated with dentoalveolar landmarks. Point M has demonstrated improved reproducibility compared with Point A because it is less affected by incisor inclination and alveolar remodeling, whereas Point G has been proposed as a stable mandibular reference because it undergoes minimal alteration during growth compared with traditional mandibular landmarks (Bharti et al., 2023; Chachada et al., 2020).

Current Evidence, Research Gap, and Relevance to the Filipino Population

Recent investigations have provided encouraging but inconsistent findings regarding the clinical applicability of the Tau angle. Bishnoi and Kamat (2023) reported significant associations between Tau-related measurements and established sagittal parameters, suggesting that Points T, M, and G may provide reliable alternatives for evaluating jaw relationships. Similarly, Kotula et al. (2022) suggested that the Tau angle may overcome several limitations associated with the ANB angle, Wits appraisal, and the Beta angle because of its reliance on stable skeletal landmarks. However, contradictory evidence regarding its reproducibility and diagnostic superiority has remained. Kotula et al. (2023) reported greater measurement errors and reduced repeatability of the Tau angle than the ANB angle, whereas Kaushik et al. (2023) demonstrated high diagnostic accuracy, particularly in identifying skeletal Class III relationships. These differences indicate that although the Tau angle has a strong theoretical basis, further validation is necessary before it can be established as a universally accepted alternative.

Moreover, existing evidence regarding the Tau angle remains limited by variations in study populations, sample characteristics, and methodological approaches. Because craniofacial morphology differs among ethnic groups, population-specific validation is essential before new cephalometric standards are adopted. Studies involving Filipino individuals and other distinct populations have emphasized the importance of establishing appropriate cephalometric norms that account for skeletal and dental variations (Hudson, 2019). Therefore, the current gap in the literature lies not only in determining whether the Tau angle correlates with established sagittal measurements but also in evaluating whether it demonstrates sufficient reliability, reproducibility, and applicability within specific populations.

Overall, the progression of cephalometric analysis demonstrates a continuous transition from traditional landmark-based assessments toward measurements that incorporate biologically stable skeletal references. Although the ANB angle remains the benchmark for sagittal jaw evaluation because of its clinical acceptance and extensive validation, its inherent limitations justify the exploration of alternative methods. The Tau angle represents a promising advancement by addressing concerns related to landmark instability and dentoalveolar influence. However, conflicting findings regarding its reliability highlight the need for further research. The present study aims to contribute to this ongoing development by evaluating the Tau angle as a potential alternative for assessing true sagittal maxillomandibular relationships and determining its applicability within the selected population.

METHODOLOGY

Design

This study utilized a **quantitative, non-experimental, retrospective, correlational research design** to evaluate the applicability of the New Tau Angle in assessing sagittal jaw disproportion and to compare its relationship with the ANB Angle, the established reference measurement for sagittal maxillomandibular assessment. The study retrospectively analyzed existing lateral cephalometric radiographs and their corresponding records obtained from a dental clinic, with no intervention or manipulation of the study subjects. Quantitative research involves the collection and statistical analysis of numerical data to examine relationships among variables and generate objective interpretations (Creswell & Creswell, 2023). A correlational research design is a non-experimental approach used to determine the degree of association between variables without manipulation or intervention by the researcher (Devi & Lecha, 2021). In this study, previously obtained cephalometric measurements from lateral cephalograms were analyzed to determine the correlation between Tau Angle and ANB Angle values, thereby assessing the agreement and potential clinical applicability of the Tau Angle as an alternative method for evaluating sagittal skeletal relationships.

Environment

The study was conducted in a private dental clinic located in Quezon City, Metro Manila, Philippines. Sagittal jaw disproportions were assessed using pretreatment lateral cephalometric radiographs obtained from selected patients who sought orthodontic consultation at the clinic. Quezon City, one of the largest and most populous cities in the National Capital Region, provides access to a diverse patient population presenting with varying sagittal skeletal relationships. Data collection was conducted from January 24–March 30, 2024 through the retrieval and review of existing patient records and pretreatment lateral cephalometric radiographs that met the established inclusion criteria.

Participants

Participants were selected using a simple random sampling technique from eligible patient records in a private dental clinic in Quezon City, Philippines. Simple random sampling is a probability sampling method in which every member of the target population has an equal chance of being selected, thereby minimizing selection bias and improving the representativeness of the sample (Bhardwaj, 2019).

An a priori sample size estimation was performed using GPower version 3.1.9.7 (Heinrich Heine University Düsseldorf, Germany) based on the primary objective of determining the relationship between ANB Angle and New Tau Angle classifications. Because Kendall's Tau-b correlation is not directly available as a statistical test option in GPower*,* the bivariate normal correlation model was used as an approximation for sample-size planning (Appendix E). Assuming a two-tailed test, a significance level of $\alpha = 0.05$, statistical power of 0.80, and an expected moderate correlation effect size of $r = 0.30$, the analysis yielded a required sample size of 84 participants. The final sample consisted of 80 eligible subjects with corresponding pretreatment lateral cephalometric radiographs who met the predefined inclusion and exclusion criteria and were available within the study period.

The study included eighty (80) pretreatment lateral cephalometric radiographs of Filipino male and female patients diagnosed with skeletal Class I, Class II, or Class III malocclusion who had undergone or were undergoing orthodontic treatment. The final sample size was based on the availability of eligible radiographic records that satisfied the predefined inclusion criteria. Only radiographs with adequate image quality and free from artifacts were included to ensure accurate cephalometric measurements.

Instruments

Cephalometric measurements were obtained through manual tracing of pretreatment lateral cephalometric radiographs using standard orthodontic tracing instruments. These included acetate matte tracing paper for landmark identification, an Ormco cephalometric protractor for angular measurements, a compass for constructing geometric landmarks required for Tau Angle analysis, a metric ruler, and a sharpened lead pencil. Sequential tracing of the lateral cephalometric radiographs was performed by outlining the cranial base, maxilla, mandible, and dentition, followed by the identification of the major cephalometric landmarks (e.g., Nasion, Sella, Point A, Point B, ANS, PNS, Pogonion, Menton, and Gonion) required for ANB Angle and Tau Angle analyses, as illustrated in **Figure 1**. The ANB Angle and Tau Angle were subsequently measured using their respective cephalometric landmarks and reference planes, as illustrated in **Figures 2 and 3**, following their standardized analytical procedures.

To ensure accuracy and consistency in landmark identification and tracing procedures, examiner calibration and expert validation were performed before and during the cephalometric analysis. Ten (10) randomly selected pretreatment lateral cephalometric radiographs were initially reviewed by three certified orthodontists to validate the identification and positioning of the relevant cephalometric landmarks required for ANB Angle and Tau Angle analyses. Following this calibration process, the researcher performed the tracing and measurements of all included radiographs. The complete set of 80 radiographs was subsequently reviewed by the three certified orthodontists, who evaluated the landmark placement, tracing accuracy, and interpretation of sagittal jaw relationships before approving the final analyses.

The measurements and interpretations were limited to the assessment of sagittal jaw disproportion among Filipino patients using the ANB Angle and Tau Angle analyses. The interpretation and classification of sagittal skeletal relationships based on the ANB Angle and Tau Angle followed the respective classification criteria presented in **Figures 2 and 3**.

Data Collection Procedure

Prior to data collection, approval to conduct the study was obtained from the Association of Philippine Orthodontists (APO), and permission was secured from the participating dental clinic to access eligible pretreatment lateral cephalometric radiographs. Eighty (80) radiographs meeting the predetermined inclusion criteria were retrieved and screened for image quality. Only clear, artifact-free pretreatment lateral cephalograms of Filipino patients with skeletal Class I, Class II, or Class III malocclusion were included. To ensure patient confidentiality, all radiographs were anonymized by assigning numerical codes before analysis.

Manual cephalometric tracings were then performed on acetate tracing paper using standard cephalometric instruments. The lateral cephalometric radiographs were sequentially traced by outlining the cranial base, maxilla, mandible, and dentition, followed by the identification of the major cephalometric landmarks required for the cephalometric analyses**,** as illustrated in Figure 1. To minimize measurement bias, the sequence of tracing and analysis was randomized.

Cephalometric landmarks for the ANB Angle (Points A, Nasion, and B) and the Tau Angle (Points T, M, and G) were identified, and the corresponding angular measurements were obtained following their respective standardized analytical procedures (Figures 2 and 3)**.** All tracings and measurements were independently verified by three certified orthodontists to ensure the accuracy and reproducibility of landmark identification.

The ANB Angle was interpreted using the normative values established for Filipinos (Naranjilla et al. (2009) as cited in Nikkerdar et al., 2019) (Figure 2)**,** whereas the Tau Angle was interpreted according to the reference values proposed by Gupta et al. (2020) (Figure 3)**.** The resulting measurements were recorded and organized for subsequent statistical analysis.

Data Analysis

Data were encoded, cleaned, and analyzed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequency and percentage, were used to summarize the demographic characteristics of the participants (age and sex) and the distribution of sagittal jaw classifications based on the ANB and Tau Angle analyses. Because the outcome variables were ordinal and the assumptions for parametric analysis were not met, nonparametric statistical tests were employed. The Kruskal–Wallis H test was used to determine differences in sagittal jaw disproportion classifications across age groups, while the Mann–Whitney U test was used to compare classifications between male and female participants (McKnight & Najab, 2010; Sherwan et al., 2022). The strength and direction of the association between the ANB Angle and Tau Angle classifications were assessed using Kendall's Tau-b correlation coefficient, an appropriate nonparametric measure for ordinal variables with tied observations (Ho et al., 2021). Correlation coefficients were interpreted as follows: <0.10, very weak; 0.10–0.19, weak; 0.20–0.29, moderate; and ≥ 0.30, strong. Statistical significance was determined using a significance level of $\alpha = 0.05$ for all analyses.

Ethical Considerations

Prior to data collection, permission to conduct the study was obtained from the Association of Philippine Orthodontists (APO), and authorization to access pretreatment lateral cephalometric radiographs was secured from the participating dental clinics. The study involved secondary analysis of existing pretreatment radiographic records obtained during routine clinical care, with no additional procedures or interventions performed on patients.

Only radiographs that satisfied the established inclusion criteria were included in the study. Patient confidentiality and privacy were strictly maintained throughout the research process by removing all personal identifiers and assigning numerical codes to each radiograph before analysis. All data were handled solely for research purposes and managed in accordance with ethical principles governing the use of clinical records and radiographic data. The study procedures were conducted in accordance with the ethical requirements and guidelines of the graduate institution and the participating organization.

Artificial intelligence (AI)-based tools were not utilized for data collection, cephalometric landmark identification, radiographic tracing, measurement determination, statistical analysis, or interpretation of study results. All landmark identification, tracing procedures, measurements, and analyses were performed manually and validated through review by certified orthodontists.

RESULTS

Out of the 80 Filipino lateral cephalometric radiographs included in the study, ANB angle analysis classified 41 subjects (51%) as Class I, 23 subjects (29%) as Class III, and 16 subjects (20%) as Class II skeletal patterns. In comparison, Tau angle analysis classified 36 subjects (45%) as Class I, 23 subjects (29%) as Class II, and 21 subjects (26%) as Class III. No significant differences in skeletal classification were observed when subjects were grouped according to age or sex using either ANB or Tau angle analysis ($p > 0.05$). However, a strong positive relationship was found between the ANB and Tau angle analyses (Kendall's Tau-b = 0.79, $p < 0.01$). This indicates that the Tau angle demonstrates substantial agreement with the ANB angle in assessing sagittal jaw disproportion and may serve as a reliable complementary diagnostic parameter.

Table 1

The Frequency and Percentage Distribution of the Subjects in terms of Age.

Age Group	*n*	%
15 years old and below	29	36.3
16–20 years old	26	32.5
21–25 years old	15	18.8
26–30 years old	3	3.8
31 years old and above	7	8.8
Total	80	100.0

Table 2

The Frequency and Percentage Distribution of the Subjects in terms of Sex.

Sex	*n*	%
Male	33	41.3
Female	47	58.8
Total	80	100.0

Figure 1.

Hard and Soft Tissue Tracings of the Cranium

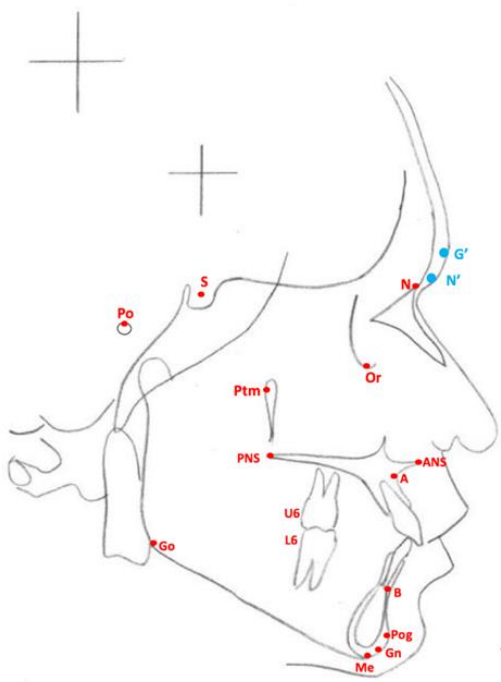
Legend:

Soft Tissue Landmarks:

G'	Soft tissue Glabella
N'	Soft tissue Nasion

Hard Tissue Landmarks:

N	Nasion
S	Sella
Or	Orbitale
Ptm	Pterygomaxillary Fissure
ANS	Anterior Nasal Spine
PNS	Posterior Nasal Spine
A	Point A
B	Point B
Pog	Pogonion
Me	Menton
U6	Upper 1st Molar
L6	Lower 1st Molar



Sequential tracing of the lateral cephalometric radiograph showing the outlines of the cranial base, maxilla, mandible, and dentition, including the identification of major cephalometric landmarks (e.g., Nasion, Sella, Point A, Point B, ANS, PNS, Pogonion, Menton, and Gonion) used for ANB and Tau angle analyses.

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Figure 2.

Tracing of Cephalometric Landmarks, Reference Planes and Type of Measurement for ***ANB Angle***

Legend

Cephalometric landmarks:

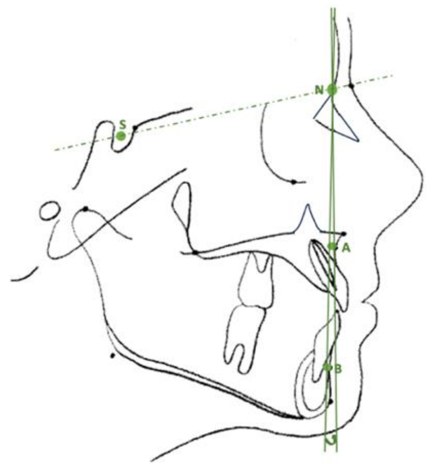
- N Nasion
- A Point A
- B Point B

Reference planes:

- S – N Plane
- N – A Plan
- N – B Plane

Type of Measurement:

- Angular Measurement



Skeletal Pattern		
Class 1	Class 2	Class 3
1.5° to 5.5 °	6° & above	Below 1.5°

Filipino Value for ANB angle (Naranjilla et al. (2009) as cited in Nikkerdar et al., 2019)

Figure 3.

Tracing of Cephalometric Landmarks, Reference Planes and Type of Measurement for Tau Angle

Legend

Cephalometric Landmarks

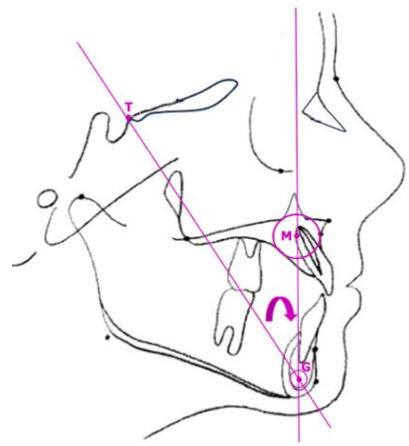
- **T** Point T
- **M** Point M
- **G** Point G

Reference planes:

- T – G plane
- M – G plane

Type of Measurement:

- Angular Measurement



Skeletal Pattern		
Class 1	Class 2	Class 3
28° to 34°	Above 34°	Below 28°

Average Value for Tau Angle (Gupta et al., 2020)

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Figure 4.

Superimposition of Point T

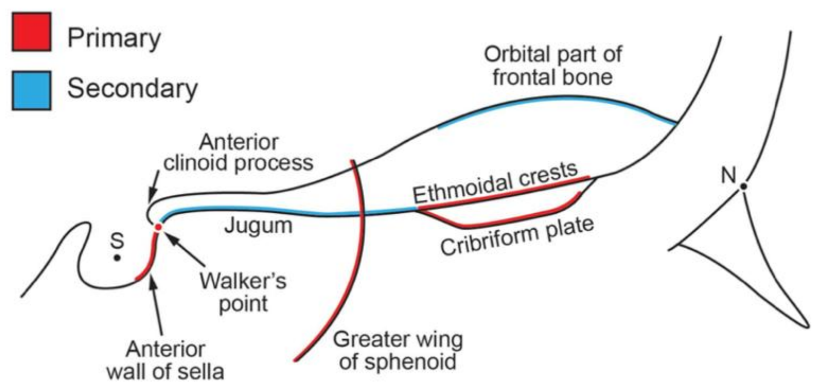

Table 3.

Types of Jaw Disproportions Present in the Assessed Cephalometric Tracings

Type of Jaw Disproportion	ANB Angle Analysis		Tau Angle Analysis	
	n	%	*n*	%
Class I	41	51.2	36	45.0
Class II	16	20.0	23	28.8
Class III	23	28.8	21	26.3
Total	80	100.0	80	100.0

Table 4.

Difference in the Type of Sagittal Jaw Disproportion Using ANB Analysis when Subjects are Grouped according to Profile

Age Group	*n*	Mean Rank	*H*	*p*
15 years and below	29	42.47	0.80	.94
16–20 years	26	38.31		
21–25 years	15	39.50		
26–30 years	3	46.50		
31 years and above	7	40.07		

Table 5.

Difference in the Type of Sagittal Jaw disproportion Using Tau Angle Analysis when Subjects are Grouped according to Profile.

Age Group	*n*	Mean Rank	*H*	*p*
15 years and below	29	44.66	2.14	.71
16–20 years	26	38.04		
21–25 years	15	38.13		
26–30 years	3	45.50		
31 years and above	7	35.36		

Table 6.

Relationship between the ANB and New Tau Angle Analyses in Assessing Sagittal Jaw Disproportion

Variables	Kendall's Tau-b (τb)	*p*	Decision
ANB Angle analysis and Tau Angle analysis	0.79	< .001	Reject H_0

DISCUSSION

The predominance of orthodontic patients aged 25 years and below in the present study **(Table 1)** suggested that younger individuals comprised the primary population seeking orthodontic treatment. This finding was consistent with Rubby et al. (2023), who reported a mean patient age of 17.9 years (range: 7–36 years). This pattern may reflect the greater demand for orthodontic treatment during adolescence and young adulthood, when concerns regarding dental appearance, facial aesthetics, and psychosocial well-being are more pronounced. The findings also supported those of Monet et al. (2022), who observed increasing interest in orthodontic treatment in the Philippines and attributed this trend to advances in dental technology, improved access to information, and increased awareness among patients and parents regarding the functional and aesthetic benefits of early orthodontic intervention.

Although the present findings provided additional local evidence regarding the age profile of orthodontic patients, they should be interpreted considering the study limitations, including the inclusion of participants from a single geographic area, which may limit the generalizability of the findings to other populations.

The predominance of female patients seeking orthodontic treatment in the present study **(Table 2)** suggested that women were more likely than men to pursue orthodontic care. This pattern may reflect greater awareness of oral health, facial aesthetics, and the psychosocial benefits associated with improved dental appearance. This finding was consistent with previous studies by Hung et al. (2023), Mathew et al. (2023), Saccomanno et al. (2023), Lagorsse and Sauty (2018), and Tang et al. (2019), which reported a higher proportion of female orthodontic patients and attributed this trend to greater aesthetic concerns, more favorable attitudes toward orthodontic treatment, and stronger motivation to improve dental appearance.

Collectively, these studies suggest that females tend to seek orthodontic treatment not only because of functional needs but also because of perceived improvements in self-confidence, attractiveness, and social well-being. These factors may contribute to better treatment compliance and satisfaction. While the consistency of the present findings with both local and international literature strengthens their credibility, the results should be interpreted with caution because the study was conducted within a single geographic setting, which may limit their applicability to other populations.

The appraisal of sagittal jaw disproportions using the ANB and Tau angles was based on standardized manual cephalometric tracing procedures and established diagnostic criteria, as described in the methodology and illustrated in **Figure 1**. Accurate assessment depended on obtaining high-quality pretreatment lateral cephalometric radiographs and the precise identification of the required cephalometric landmarks to ensure reliable angular measurements. The ANB angle was used to evaluate the anteroposterior relationship between the maxilla and mandible, whereas the Tau angle provided an alternative assessment of sagittal skeletal relationships that is less influenced by variations in cranial base length and jaw rotation. The angular measurements obtained from both analyses were subsequently interpreted to classify sagittal skeletal relationships as Class I, Class II, or Class III according to established cephalometric standards.

Table 3 findings indicated that most assessed cephalometric tracings were classified as Class I by both the ANB and Tau angle analyses, suggesting that the two methods generally agree in identifying subjects with normal sagittal skeletal relationships. However, differences in skeletal classification were observed in a small number of subjects, particularly among those with borderline ANB values and dentoalveolar compensations.

Subjects with an ANB angle of 5.5° were classified as Class I using the Filipino norm but were classified as Class II using the Tau angle. Subjects No. 10, 16, 27, and 71 exhibited ANB angles of 5.5°, interpreted as skeletal Class I patterns, but were classified as skeletal Class II based on Tau angle values of 35°–36°. This discrepancy may be attributed to the prognathic craniofacial characteristics commonly observed among Filipino individuals, which may influence ANB-based classification within Filipino norms but result in a different interpretation using Tau angle reference values (Figure 5).

This finding suggests that the Tau angle may be more sensitive in detecting mild skeletal discrepancies because it relies on stable skeletal landmarks that are less influenced by cranial base length, jaw rotation, and dentoalveolar compensation. This observation was consistent with Nikkerdar et al. (2019), who reported that Filipinos commonly exhibit bimaxillary protrusion, increased SNA and SNB angles, and an elongated anterior cranial base, characteristics that may influence ANB angle interpretation.

Although previous literature has identified potential landmark identification errors associated with the use of the Tau angle, particularly in non-calibrated or less standardized cephalometric settings, the Tau landmarks in the present study were considered viable for analysis because the measurements were performed using standardized manual cephalometric tracing procedures and clearly defined anatomical landmarks. High-quality pretreatment lateral cephalometric radiographs were used, and the landmarks required for Tau angle measurement were identified consistently according to the established cephalometric criteria described in the methodology. These standardized procedures reduced the likelihood of variability arising from differences in landmark localization and ensured that the angular measurements were obtained using the same reference points across all subjects. Therefore, although landmark identification remains a potential source of measurement error, the controlled tracing conditions and systematic landmark identification employed in this study supported the reliability and clinical applicability of the Tau angle measurements. Nevertheless, the possibility of minor identification error cannot be completely excluded and should be considered when interpreting differences between the ANB and Tau angle classifications.

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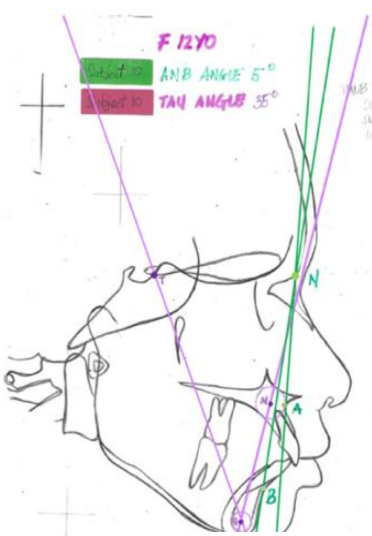
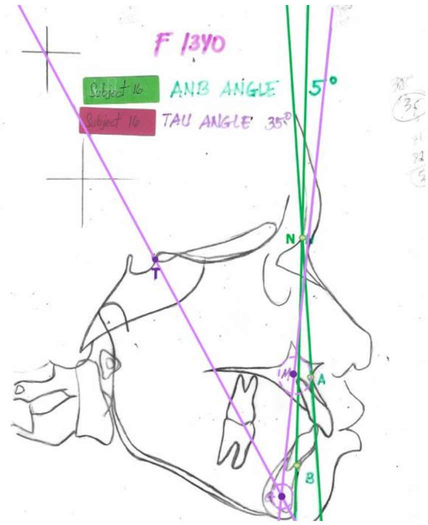
Figure 5.

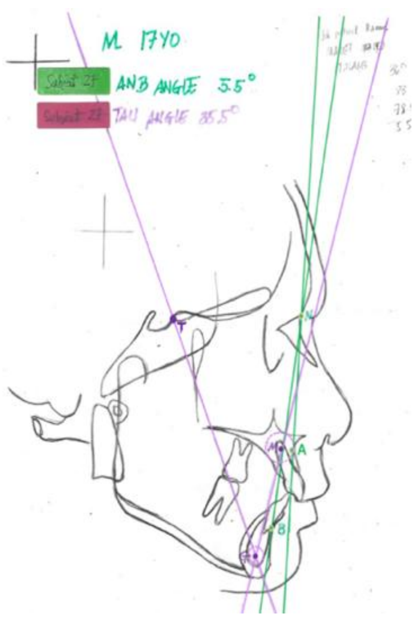
Superimposition of ANB and Tau angles tracings of subject no: 10, 16, 27 and 71 Presenting Different Interpretation as Class 1 and Class 2 Skeletal Pattern.



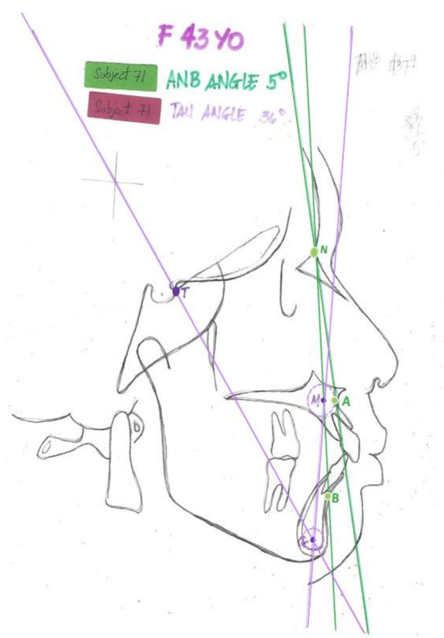
Subject No. 10



Subject No. 16



Subject No. 27



Subject No. 71

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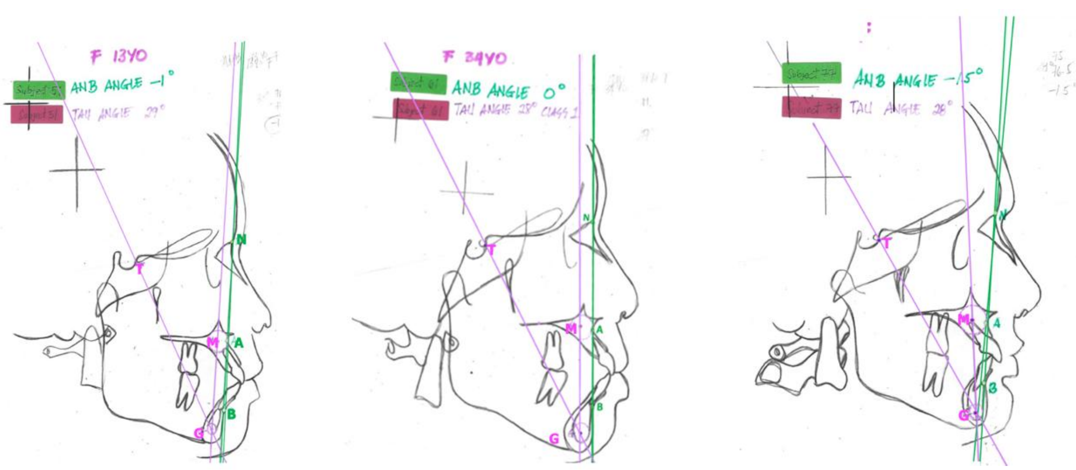
Likewise, subjects with pronounced convex facial profiles were consistently identified as Class II by both methods, supporting Nguyen's (2023) findings that mandibular retrusion, shorter cranial base dimensions, and clockwise mandibular rotation are characteristic features of skeletal Class II malocclusion. Conversely, discrepancies in Class III classification appeared to result from the influence of Point A and Point B positions on the ANB angle, which are affected by incisor inclination, whereas the Tau angle evaluates the true sagittal relationship of the maxilla and mandible using skeletal centroids. In the study, subjects 51, 61, and 77 were classified as skeletal Class III based on ANB angle measurements but were classified as skeletal Class I using the Tau angle. This discrepancy may be attributed to the influence of incisor proclination on Points A and B, which affected ANB interpretation. In contrast, the Tau angle assessed the sagittal relationship using stable skeletal centroid landmarks of the maxilla and mandibular symphysis, providing a representation of true jaw position (Figure 6).

Figure 6.

Superimposition of ANB and Tau Angle Tracings for Subject nos. 51, 61 and 77 Interpreted Differently as Class 1 and 3 Skeletal Patterns.



Subject No. 51 Subject No. 61 Subject No. 77

This finding supported Li et al. (2024), who emphasized that maxillary morphology and dentoalveolar compensation significantly affect the presentation of skeletal Class III malocclusion, and agreed with Gupta et al. (2020) and Kaushik et al. (2023), who concluded that the Tau angle provides reliable discrimination among Class I, Class II, and Class III skeletal patterns. Although these findings should be interpreted with caution because they were derived from a single-center sample of Filipino subjects, the study strengthened evidence supporting the complementary use of the Tau angle with the conventional ANB angle, particularly in borderline cases and populations with ethnic craniofacial characteristics that may affect traditional cephalometric measurements.

Table 4 findings indicated that sagittal jaw disproportions determined using ANB analysis did not differ significantly according to age or sex, suggesting that ANB-based skeletal classification was generally consistent across the demographic groups included in the study. Although descriptive trends showed slightly higher ANB values among female subjects, particularly within Class I and Class II skeletal patterns, these differences were not statistically significant and therefore should not be interpreted as evidence of true sex- or age-related variation.

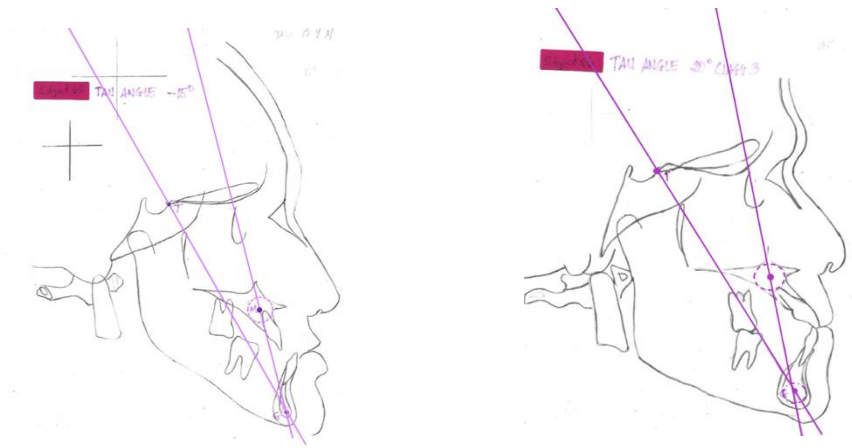
The observed tendency for females to demonstrate relatively higher ANB values may reflect the greater facial convexity, bimaxillary protrusion, and clockwise mandibular rotation commonly reported among Filipino females, as described by Moldez et al. (cited in Uozo et al., 2020) and Naranjilla and Rudzki-Janson (as cited in Nikkerdar et al., 2019). Likewise, the tendency for male subjects to exhibit lower ANB values within the Class III group was consistent with Kumar and Ravikumar (2022), who reported a higher prevalence of skeletal Class III malocclusion among males, particularly during adolescence.

However, because these trends did not reach statistical significance, they may be attributed to the relatively small number of subjects within each age and sex subgroup, which may have limited the study’s ability to detect subtle demographic differences. Despite this limitation, the study provided valuable evidence that ANB analysis yields stable skeletal classifications regardless of patient age or sex within this Filipino sample.

Table 5 findings indicated that sagittal jaw disproportions assessed using the Tau angle did not differ significantly according to age or sex, suggesting that the Tau angle provided a consistent evaluation of skeletal relationships across demographic groups. Although descriptive patterns showed that females had a wider range of Class II Tau values, while males demonstrated more severe Class III discrepancies (Figure 7), these differences were not statistically significant and may have been influenced by the limited number of subjects per subgroup.

Figure 7.

Tracing of Male Subjects No. 66 and 68 with Tau angles 15º and 20º Respectively, Demonstrating the Greatest Disproportion among 80 Samples.



Subject 66 Subject 68

The predominance of higher Class I Tau values among both sexes reflected the characteristic prognathic facial pattern commonly reported among Filipinos, which has been associated with horizontal maxillary and mandibular growth and an elongated anterior cranial base (Esporlas, 2018; Nikkerdar et al., 2019). Unlike the ANB angle, the Tau angle utilizes more stable skeletal landmarks and is less affected by cranial base variation and mandibular rotation, allowing a more reliable assessment of true sagittal jaw relationships (Gupta et al., 2020; Kumar et al., 2023).

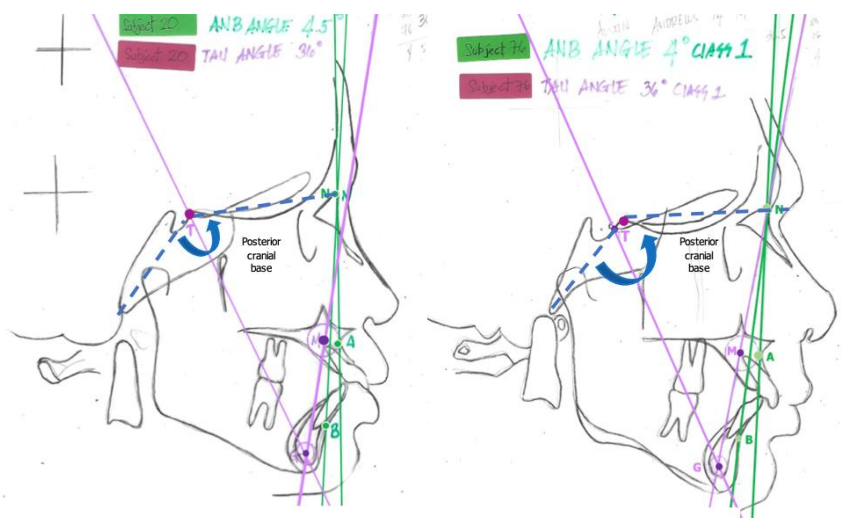
The greater variation among female Class II subjects may be related to differences in craniofacial morphology and mandibular positioning, while the more severe Class III discrepancies observed among male subjects were consistent with reports of higher Class III prevalence among males (Thirumalgal et al., 2022). Despite the limitation of a relatively small sample size, these findings supported the clinical applicability of the Tau angle as a reliable adjunct for assessing sagittal jaw disproportions in Filipino patients.

Table 6 findings demonstrated a strong positive correlation between the ANB and Tau angle analyses (Tb = 0.79, $p < 0.01$), indicating that both methods generally provided comparable assessments of sagittal jaw disproportion. However, differences in classification were observed in nine out of eighty subjects, particularly among borderline cases, highlighting the influence of craniofacial characteristics and the limitations of relying on a single cephalometric measurement.

Subjects classified as Class I using ANB but Class II using the Tau angle exhibited borderline ANB values (4.0°–5.5°) (Figure 8), suggesting that the Tau angle may detect mild sagittal discrepancies influenced by Filipino craniofacial characteristics, such as bimaxillary protrusion and increased cranial base inclination (Nikkerdar et al., 2019). Conversely, subjects classified as Class III using ANB but Class I using the Tau angle demonstrated the effect of dentoalveolar compensation, particularly incisor proclination, which can alter the position of Points A and B and influence ANB interpretation. (Figure 6)

Figure 8

Superimposition of ANB and Tau Angles Tracings of Subject Nos. 20 and 76 with Different Interpretations Resulted from an Increased Inclination of Posterior Cranial Base.



Subject 20 Subject 76

Because the Tau angle evaluates the sagittal relationship using skeletal centroid points in relation to the stable T point, it may provide a more accurate representation of the underlying jaw relationship rather than dentoalveolar position. In the study, subjects 20 and 76 exhibited ANB angles of 4.5° and 4.0°, respectively, which were interpreted as Class I skeletal patterns. However, both subjects demonstrated Tau angles of 36°, corresponding to Class II skeletal patterns. This discrepancy may be attributed to increased posterior cranial base inclination affecting interpretation (Figure7). These findings supported the complementary use of ANB and Tau angle analyses, particularly in borderline cases and populations with distinct craniofacial characteristics.

Despite the limitation of a relatively small sample size, the strong agreement between the two methods suggested that the Tau angle may serve as a valuable adjunct to conventional ANB analysis in improving the accuracy of sagittal skeletal diagnosis among Filipino patients.

Overall, the findings of this study demonstrated that both ANB and Tau angle analyses were effective in evaluating sagittal jaw relationships among Filipino patients. The significant correlation between the two methods indicated that the Tau angle has potential as a complementary diagnostic measurement, particularly in cases where conventional ANB interpretation may be affected by cranial base morphology, mandibular rotation, or dentoalveolar compensation.

Although ANB remains the conventional standard for sagittal skeletal assessment because of its extensive validation and clinical acceptance, the Tau angle offers an alternative approach based on more stable skeletal references. The present findings supported the continued investigation of Tau angle reliability and applicability in different populations, particularly among groups with distinct craniofacial characteristics. Further studies with larger and more diverse samples are needed to establish population-specific norms and confirm the diagnostic performance of the Tau angle.

CONCLUSION

The study concludes that the assessment of sagittal jaw disproportion using ANB and Tau angle analyses provides valuable information for evaluating sagittal skeletal relationships among Filipino orthodontic patients. The subjects are predominantly from younger age groups, with a higher proportion of females, reflecting the demographic characteristics of the assessed orthodontic population. Accurate evaluation of sagittal discrepancies depends on the quality of lateral cephalometric radiographs and the precise identification of cephalometric landmarks, particularly those required for Tau angle analysis.

Both ANB and Tau angle analyses demonstrate comparable classifications of sagittal jaw relationships, although some differences are observed in borderline cases, which may be attributed to variations in craniofacial morphology and the influence of dentoalveolar factors on conventional ANB measurements. The findings further reveal that age and sex do not significantly affect the classification of sagittal jaw disproportion, indicating that both methods can be applied consistently across demographic groups.

Moreover, the strong positive correlation between ANB and Tau angle analyses confirms that the Tau angle can serve as a reliable adjunct to ANB analysis in assessing sagittal jaw discrepancies. Overall, the study supports the clinical utility of combining ANB and Tau angle measurements to improve the accuracy of sagittal skeletal diagnosis, particularly in populations with distinct craniofacial characteristics such as Filipinos.

Future studies will further evaluate the reliability, reproducibility, and diagnostic performance of the Tau angle using larger and more diverse populations. Additional research will establish population-specific normative values and will determine the broader clinical applicability of Tau angle analysis in orthodontic diagnosis and treatment planning.

RECOMMENDATIONS

For Orthodontic Practitioners: The Tau angle serves as a complementary or alternative cephalometric parameter to the ANB angle, particularly in cases where conventional ANB landmarks are difficult to identify accurately or are affected by anatomical variations. Its use improves the assessment of sagittal skeletal relationships and supports more reliable diagnostic decision-making.

For Orthodontic Educators and Students: Greater emphasis should be placed on the proper identification, tracing, and interpretation of the cephalometric landmarks required for Tau angle analysis. Strengthening training in this technique may enhance diagnostic accuracy and increase familiarity with emerging cephalometric parameters.

For Developers of Orthodontic Artificial Intelligence (AI) Software: The incorporation of Tau angle analysis into digital cephalometric tracing systems is recommended to improve diagnostic efficiency, expand AI-assisted orthodontic assessment, and provide clinicians with additional tools for evaluating sagittal skeletal discrepancies.

For Future Researchers: Further studies involving larger and more diverse Filipino populations are recommended to establish population-specific normative values for the Tau angle. Future investigations should also evaluate its reliability, validity, and clinical applicability across different age groups and skeletal malocclusion classifications to strengthen the evidence supporting its use in orthodontic diagnosis.

List of Abbreviations

ANB Angle: Point A- Nasion Point – Point B angle
APO: Association of Philippine Orthodontists

Declarations

Ethical approval and consent to participate

This study employed a retrospective research design using existing pretreatment lateral cephalometric radiographs; therefore, Institutional Ethics Review Board approval was not applicable. Prior to data collection, permission to conduct the study was obtained from the Association of Philippine Orthodontists (APO), and authorization to access pretreatment lateral cephalometric radiographs was secured from the participating dental clinics. The study utilized existing radiographic records that had been obtained as part of routine clinical care. All radiographs were de-identified prior to analysis, with all personal identifiers removed to ensure patient confidentiality and privacy. The data were used exclusively for research purposes and were handled in accordance with applicable ethical principles governing the use of patient records. As the study involved only anonymized existing records and no direct patient contact or intervention, informed consent to participate was not required.

Consent for publication

Not applicable – no individual participant data reported.

Availability of data and materials

All data generated or analyzed are included in this published article and its supplementary files.

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Declaration of Generative AI and AI-assisted Technologies

The author acknowledges the use of ChatGPT (GPT-5.5, OpenAI) to improve language clarity, enhance grammar, refine sentence structure, and improve the overall academic presentation of this dissertation. Prompts used included: *"Please streamline this paragraph into one short paragraph,"* *"Please improve the grammar and academic tone while preserving the original meaning,"* and *"Please proofread and enhance this text for clarity and conciseness."* The AI-generated output was used solely to improve the readability, grammatical accuracy, and organization of the manuscript. All research design, data collection, analysis, interpretation of findings, and conclusions were conducted independently by the author. The author, Annie Laine F. Luat, is the sole author of this dissertation and accepts full responsibility for its content, in accordance with COPE recommendations and institutional policies.

Competing Interests

None declared.

Author's contributions

The author, Annie Laine F. Luat, was responsible for all aspects of the research process, including conceptualization, methodology development, formal analysis, writing of the original draft, visualization, and project administration. The author independently designed the study, established the research methods, analyzed and interpreted the findings, prepared the manuscript, developed the necessary visual materials, and managed the overall implementation of the research project.

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