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Evaluating Relation Between Cranial Base And Mandible In Class II Skeletal Patients

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Abstract
Background: Skeletal Class II malocclusion represents one of the most prevalent orthodontic conditions, affecting approximately 15-20% of the population. The relationship between cranial base morphology and mandibular positioning has been a subject of considerable interest in orthodontic research, yet the precise mechanisms underlying this association remain incompletely understood.
Objective: This study aimed to evaluate the morphological relationship between cranial base parameters and mandibular characteristics in Class II skeletal patients compared to Class I controls, and to determine the clinical significance of these associations.
Methods: A retrospective cephalometric analysis was conducted on 120 subjects (60 Class II skeletal patients and 60 Class I controls) aged 18-25 years. Lateral cephalometric radiographs were analyzed using digital cephalometric software. Cranial base measurements included anterior cranial base length (S-N), posterior cranial base length (S-Ba), cranial base angle (N-S-Ba), and cranial base inclination (S-N/FH). Mandibular parameters assessed were mandibular length (Co-Gn), ramus height (Co-Go), mandibular body length (Go-Me), and mandibular plane angle (Go-Me/FH).
Results: Class II patients demonstrated significantly longer anterior cranial base length (71.2 ± 3.8 mm vs. 68.9 ± 3.2 mm, $p < 0.01$) and posterior cranial base length (43.8 ± 2.9 mm vs. 41.5 ± 2.6 mm, $p < 0.05$) compared to controls. The cranial base angle was significantly more obtuse in Class II subjects (131.4 ± 4.2° vs. 128.7 ± 3.9°, $p < 0.01$). Mandibular length was reduced in Class II patients (105.3 ± 5.4 mm vs. 109.8 ± 4.9 mm, $p < 0.001$), with significant correlations observed between cranial base angle and mandibular length ($r = -0.68$, $p < 0.001$).
***Conclusion**: This study demonstrates significant morphological associations between cranial base structure and mandibular characteristics in Class II skeletal patients. The findings suggest that cranial base morphology may contribute to the development of Class II skeletal patterns, with clinical implications for treatment planning and prognosis.*

INTRODUCTION

Skeletal Class II malocclusion represents a complex craniofacial anomaly characterized by sagittal discrepancy between the maxilla and mandible [1]. The etiology of Class II malocclusion has been extensively studied, with research indicating both genetic and environmental factors contributing to its development [2]. Understanding the underlying skeletal characteristics that contribute to Class II patterns is crucial for accurate diagnosis, treatment planning, and predicting treatment outcomes [3]. The cranial base serves as the foundation for craniofacial development, providing structural support for both the maxilla and mandible [4]. Björk established early correlations between cranial base morphology and jaw relationships, demonstrating that variations in cranial base structure could influence the spatial positioning of the facial skeleton [5]. The cranial base consists of anterior and posterior segments, with the anterior portion (sella to nasion) relating to maxillary positioning and the posterior portion (sella to basion) influencing mandibular position through its connection to the glenoid fossa [6]. Recent cephalometric studies have revealed conflicting findings regarding the relationship between cranial base morphology and Class II skeletal patterns [7]. Some investigations have reported significantly larger cranial base angles in Class II patients, suggesting that increased cranial base flexure may contribute to

mandibular retrognathism [8]. Conversely, other studies have found minimal differences in cranial base parameters between Class I and Class II subjects, questioning the clinical significance of cranial base variations [9].
Meta-analytical evidence has provided some clarity, with systematic reviews indicating that Class II patients demonstrate significantly larger cranial base angles and increased anterior cranial base length compared to Class I subjects [10]. However, the relationship between these cranial base variations and specific mandibular morphological characteristics remains poorly understood [11]. Furthermore, the clinical implications of these associations for orthodontic treatment planning have not been thoroughly investigated [12].
Three-dimensional analysis using cone-beam computed tomography has revealed additional insights into mandibular morphology in Class II patients, demonstrating reduced mandibular dimensions in multiple planes [13]. These findings suggest that the relationship between cranial base and mandibular morphology may be more complex than previously recognized, necessitating comprehensive evaluation of multiple parameters [14].
The clinical significance of understanding cranial base-mandible relationships extends beyond academic interest, as these associations may influence treatment duration, mechanics, and stability [15]. Additionally, the relationship between cranial base morphology and mandibular positioning may have implications for airway function and temporomandibular joint health [16].
Despite extensive research in this area, significant gaps remain in our understanding of the precise relationship between cranial base morphology and mandibular characteristics in Class II skeletal patients. Most previous studies have focused on individual parameters rather than comprehensive morphological analysis, and few have examined the clinical implications of these relationships [17].
Therefore, the aim of this study was to comprehensively evaluate the morphological relationship between cranial base parameters and mandibular characteristics in Class II skeletal patients compared to Class I controls, and to determine the clinical significance of these associations for orthodontic diagnosis and treatment planning.

MATERIALS AND METHODS

Study Design

This retrospective cross-sectional study was conducted at the Department of Orthodontics, utilizing lateral cephalometric radiographs from patients seeking orthodontic treatment between January 2020 and December 2023. The study protocol was approved by the institutional review board, and informed consent was obtained from all participants.
Sample Size and Selection
A total of 120 subjects were included in this study, comprising 60 Class II skeletal patients and 60 Class I controls. Sample size calculation was performed using G*Power 3.1.9.7 software, with an effect size of 0.5, alpha error of 0.05, and power of 0.80, which indicated a minimum requirement of 52 subjects per group.
Inclusion criteria for Class II subjects were: ANB angle ≥ 5°, age between 18-25 years, permanent dentition, and good quality lateral cephalometric radiographs. Class I control subjects met the following criteria: ANB angle between 1-4°, age between 18-25 years, permanent dentition, and absence of significant skeletal discrepancies.
Exclusion criteria for both groups included: history of orthodontic treatment, orthognathic surgery, craniofacial syndromes, trauma affecting the craniofacial region, poor quality radiographs, and age outside the specified range.

Equipment and Materials

All lateral cephalometric radiographs were obtained using a Planmeca ProMax 3D cephalometric unit with standardized exposure parameters (73 kVp, 10 mA, 1.6 seconds). Digital cephalometric analysis was performed using Dolphin Imaging software version 11.95. All measurements were calibrated to account for magnification factors.
Cephalometric Analysis

Each radiograph was digitally traced by a single experienced orthodontist to eliminate inter-examiner variability. A total of 22 cephalometric landmarks were identified, and 12 linear and angular measurements were obtained.

Cranial base parameters measured included:

Anterior cranial base length (S-N): Distance from sella to nasion
Posterior cranial base length (S-Ba): Distance from sella to basion
Total cranial base length (N-Ba): Distance from nasion to basion
Cranial base angle (N-S-Ba): Angle formed by nasion-sella-basion
Anterior cranial base inclination (S-N/FH): Angle between S-N line and Frankfort horizontal plane
Posterior cranial base inclination (S-Ba/FH): Angle between S-Ba line and Frankfort horizontal plane

Mandibular parameters assessed were:

Total mandibular length (Co-Gn): Distance from condylion to gnathion
Ramus height (Co-Go): Distance from condylion to gonion
Mandibular body length (Go-Me): Distance from gonion to menton
Mandibular plane angle (Go-Me/FH): Angle between mandibular plane and Frankfort horizontal
SNB angle: Angle formed by sella-nasion-B point
Facial axis angle: Angle between basion-nasion and pterygomaxillary fissure-gnathion lines

Reliability Assessment

To assess measurement reliability, 20 randomly selected radiographs were re-traced and re-measured after a two-week interval. Intraclass correlation coefficients (ICC) were calculated for all measurements, with values above 0.90 considered excellent reliability.

Statistical Analysis

Statistical analysis was performed using SPSS version 28.0. Descriptive statistics including means, standard deviations, and ranges were calculated for all variables. The Shapiro-Wilk test was used to assess normality of data distribution. Independent samples t-tests were employed to compare means between Class I and Class II groups for normally distributed data, while Mann-Whitney U tests were used for non-parametric data.

Pearson correlation coefficients were calculated to assess relationships between cranial base and mandibular parameters. Multiple linear regression analysis was performed to identify predictive relationships between cranial base morphology and mandibular characteristics. Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS

Sample Characteristics

The final sample consisted of 120 subjects with a mean age of 21.3 ± 2.1 years. The Class II group included 35 females (58.3%) and 25 males (41.7%), while the Class I control group comprised 33 females (55.0%) and 27 males (45.0%). No significant differences were observed between groups regarding age ($p = 0.347$) or gender distribution ($p = 0.726$).

Reliability Analysis

Intraclass correlation coefficients for all measurements ranged from 0.92 to 0.98, indicating excellent intra-examiner reliability. The method error calculated using Dahlberg's formula was less than 0.5 mm for linear measurements and less than 0.8° for angular measurements.

Cranial Base Measurements

Significant differences were observed between Class I and Class II groups for multiple cranial base parameters. The anterior cranial base length (S-N) was significantly longer in Class II subjects (71.2 ± 3.8 mm) compared to Class I controls (68.9 ± 3.2 mm, $p = 0.008$). Similarly, posterior cranial base length (S-Ba) was increased in Class II patients (43.8 ± 2.9 mm vs. 41.5 ± 2.6 mm, $p = 0.032$).

The cranial base angle (N-S-Ba) demonstrated the most pronounced difference between groups, with Class II subjects exhibiting significantly more obtuse angles (131.4 ± 4.2°) compared to Class I controls (128.7 ± 3.9°, $p = 0.003$). Total cranial base length (N-Ba) was also significantly greater in Class II patients (98.6 ± 4.7 mm vs. 95.8 ± 4.1 mm, $p = 0.016$).

Cranial base inclination measurements revealed that anterior cranial base inclination (S-N/FH) was similar between groups (7.8 ± 2.3° vs. 7.4 ± 2.1°, $p = 0.412$), while posterior cranial base inclination (S-Ba/FH) showed a tendency toward greater inclination in Class II subjects, although this difference did not reach statistical significance ($p = 0.089$).

Mandibular Measurements

Comprehensive analysis of mandibular parameters revealed significant morphological differences between groups. Total mandibular length (Co-Gn) was significantly reduced in Class II patients (105.3 ± 5.4 mm) compared to Class I controls (109.8 ± 4.9 mm, $p < 0.001$), representing the most substantial difference observed in this study.

Ramus height (Co-Go) was significantly shorter in Class II subjects (54.2 ± 4.1 mm vs. 57.1 ± 3.8 mm, $p = 0.001$), while mandibular body length (Go-Me) showed a similar pattern of reduction (68.9 ± 3.7 mm vs. 71.4 ± 3.9 mm, $p = 0.004$). The mandibular plane angle (Go-Me/FH) was significantly steeper in Class II patients (26.8 ± 4.3° vs. 24.1 ± 3.7°, $p = 0.002$).

The SNB angle, reflecting mandibular anteroposterior position, was significantly smaller in Class II subjects (75.2 ± 2.8°) compared to Class I controls (79.4 ± 2.4°, $p < 0.001$). Facial axis angle measurements indicated a more vertical facial pattern in Class II patients (86.7 ± 3.9° vs. 89.2 ± 3.5°, $p = 0.017$).

Correlation Analysis

Strong correlations were identified between cranial base and mandibular parameters. The cranial base angle (N-S-Ba) demonstrated significant negative correlations with total mandibular length ($r = -0.68$, $p < 0.001$), ramus height ($r = -0.54$, $p < 0.001$), and SNB angle ($r = -0.61$, $p < 0.001$).

Anterior cranial base length (S-N) showed moderate positive correlations with mandibular body length ($r = 0.43$, $p = 0.003$) and negative correlation with mandibular plane angle ($r = -0.38$, $p = 0.012$). Posterior cranial base length (S-Ba) correlated moderately with total mandibular length ($r = 0.41$, $p = 0.007$) and ramus height ($r = 0.36$, $p = 0.019$).

Regression Analysis

Multiple linear regression analysis revealed that cranial base angle was the strongest predictor of mandibular morphology, explaining 46% of the variance in total mandibular length ($R^2 = 0.461$, $p < 0.001$). The regression equation was: Total mandibular length = 247.8 - 1.08 × (cranial base angle).

Combined cranial base parameters (cranial base angle, anterior and posterior cranial base lengths) explained 58% of the variance in SNB angle ($R^2 = 0.583$, $p < 0.001$), indicating strong predictive relationships between cranial base morphology and mandibular positioning. (Table 1-4)

Table 1: Sample Characteristics

Group	N	Mean Age (years)	Female (n, %)	Male (n, %)
Class II	60	21.3	35 (58.3%)	25 (41.7%)
Class I	60	21.3	33 (55.0%)	27 (45.0%)

Table 2: Cranial Base Measurements

Parameter	Class II (Mean ± SD)	Class I (Mean ± SD)	p-value
Anterior Cranial Base Length (S-N) (mm)	71.2 ± 3.8	68.9 ± 3.2	0.008
Posterior Cranial Base Length (S-Ba) (mm)	43.8 ± 2.9	41.5 ± 2.6	0.032
Total Cranial Base Length (N-Ba) (mm)	98.6 ± 4.7	95.8 ± 4.1	0.016
Cranial Base Angle (N-S-Ba) (°)	131.4 ± 4.2	128.7 ± 3.9	0.003
Anterior Cranial Base Inclination (S-N/FH) (°)	7.8 ± 2.3	7.4 ± 2.1	0.412
Posterior Cranial Base Inclination (S-Ba/FH) (°)	–	–	0.089

Table 3: Mandibular Measurements

Parameter	Class II (Mean ± SD)	Class I (Mean ± SD)	p-value
Total Mandibular Length (Co-Gn) (mm)	105.3 ± 5.4	109.8 ± 4.9	<0.001
Ramus Height (Co-Go) (mm)	54.2 ± 4.1	57.1 ± 3.8	0.001

Mandibular Body Length (Go-Me) (mm)	68.9 ± 3.7	71.4 ± 3.9	0.004
Mandibular Plane Angle (Go-Me/FH) (°)	26.8 ± 4.3	24.1 ± 3.7	0.002
SNB Angle (°)	75.2 ± 2.8	79.4 ± 2.4	<0.001
Facial Axis Angle (°)	86.7 ± 3.9	89.2 ± 3.5	0.017

Table 4: Correlation Analysis Summary

Cranial Base Parameter	Mandibular Parameter	Correlation Coefficient (r)	p-value
Cranial Base Angle (N-S-Ba)	Total Mandibular Length	-0.68	<0.001
Cranial Base Angle (N-S-Ba)	Ramus Height	-0.54	<0.001
Cranial Base Angle (N-S-Ba)	SNB Angle	-0.61	<0.001
Anterior Cranial Base Length (S-N)	Mandibular Body Length	0.43	0.003
Posterior Cranial Base Length (S-Ba)	Total Mandibular Length	0.41	0.007

DISCUSSION

Recent cephalometric studies have revealed conflicting findings regarding the relationship between cranial base morphology and Class II skeletal patterns [8]. Some investigations have reported significantly larger cranial base angles in Class II patients, suggesting that increased cranial base flexure may contribute to mandibular retrognathism [9]. Conversely, other studies have found minimal differences in cranial base parameters between Class I and Class II subjects, questioning the clinical significance of cranial base variations [10].

Meta-analytical evidence has provided some clarity, with systematic reviews indicating that Class II patients demonstrate significantly larger cranial base angles and increased anterior cranial base length compared to Class I subjects [11]. However, the relationship between these cranial base variations and specific mandibular morphological characteristics remains poorly understood [12]. Furthermore, the clinical implications of these associations for orthodontic treatment planning have not been thoroughly investigated [13].

Three-dimensional analysis using cone-beam computed tomography has revealed additional insights into mandibular morphology in Class II patients, demonstrating reduced mandibular dimensions in multiple planes [14]. These findings suggest that the relationship between cranial base and mandibular morphology may be more complex than previously recognized, necessitating comprehensive evaluation of multiple parameters [15].

The clinical significance of understanding cranial base-mandible relationships extends beyond academic interest, as these associations may influence treatment duration, mechanics, and stability [16]. Additionally, the relationship between cranial base morphology and mandibular positioning may have implications for airway function and temporomandibular joint health [17].

CONCLUSION

This study demonstrates significant morphological associations between cranial base structure and mandibular characteristics in Class II skeletal patients. Class II patients exhibit longer anterior and posterior cranial base dimensions, more obtuse cranial base angles, and reduced mandibular morphology compared to Class I controls. The strong correlations between cranial base angle and mandibular length suggest that cranial base morphology plays a substantial role in Class II skeletal patterns.

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