

Pathognomonic Cephalometric Characteristics of Angle Class II Division 2 Malocclusion

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Abstract: The Class II division 2 (Class II/2) malocclusion as originally defined by E.H. Angle is relatively rare. The orthodontic literature does not agree on the skeletal characteristics of this malocclusion. Several researchers claim that it is characterized by an orthognathic facial pattern and that the malocclusion is dentoalveolar per se. Others claim that the Class II/2 malocclusion has unique skeletal and dentoalveolar characteristics. The present study describes the skeletal and dentoalveolar cephalometric characteristics of 50 patients clinically diagnosed as having Class II/2 malocclusion according to Angle's original criteria. The study compares the findings with those of both a control group of 54 subjects with Class II division 1 (Class II/1) malocclusion and a second control group of 34 subjects with Class I (Class I) malocclusion. The findings demonstrate definite skeletal and dentoalveolar patterns with the following characteristics: (1) the maxilla is orthognathic, (2) the mandible has relatively short and retrognathic parameters, (3) the chin is relatively prominent, (4) the facial pattern is hypodivergent, (5) the upper central incisors are retroclined, and (6) the overbite is deep. The results demonstrate that, in a sagittal direction, the entity of Angle Class II/2 malocclusion might actually be located between the Angle Class I and the Angle Class II/1 malocclusions, with unique vertical skeletal characteristics. (*Angle Orthod* 2002;72:251–257.)

Key Words: Malocclusion; Class II division 2

INTRODUCTION

The Angle Class II division 2 (Class II/2) malocclusion is relatively rare. Its frequency lies between 1.5 and 5% of all malocclusions found in a white western population.^{1,2} Angle's original definition of Class II/2 malocclusion, as it appears in the 7th edition of the *Treatment of Malocclusion of the Teeth and Fractures of the Maxillae*,³ is comprehensive. Because of the absence of radiographic assessments at that time, Angle's definition is based on the clinical presentation of the dentoalveolar pattern.

Over the years, the original definition was modified and eroded.^{4–15} Orthodontists simplified the definition of Class

II/2 malocclusion by characterizing it as a malocclusion in which the molars and canines are in distocclusion and the upper central incisors are retroclined.

Whether patients demonstrating clinical Class II/2 malocclusion have an underlying pathognomonic skeletal as well as dentoalveolar pattern is an ongoing debate in the literature. A number of cephalometric studies have tried to answer these questions.^{16–37} However, several of these studies included relatively small experimental samples,^{16–18,23–26,35,37} whereas others did not describe the exact criteria for sample selection.^{16,17,19–22,26,32,33} Moreover, in the majority of these papers, the Class II/2 malocclusion group was not selected according to Angle's original definition.

This research had three objectives:

- To describe the skeletal and dental cephalometric characteristics of Class II/2 malocclusion group, selected according to Angle's original definition
- To compare a Class II/2 malocclusion group to Class II/1 and Class I groups with similar age distributions
- To define, if possible, the sagittal and vertical position of Class II/2 malocclusion relative to Class I and Class II/1 malocclusions

MATERIALS AND METHODS

The experimental data consisted of the records of 50 patients who fit Angle's original criteria for a Class II/2 malocclusion.

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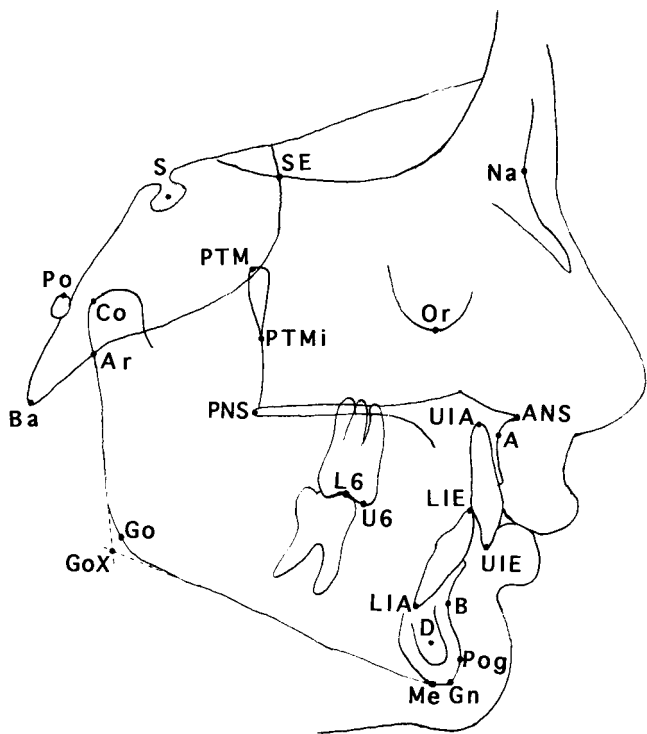


FIGURE 1. Cephalometric landmarks for each head film. Skeletal measurements: 1. SNA (degrees); 2. Point A to nasion perpendicular (A to Na Perp) (millimeters); 3. Condylion to point A (Co-A) (millimeters); 4. Distance between projections from points ANS and PTMi to the Frankfort Horizontal plane (ANSFH-PTMiFH) millimeters); 5. SNB (degrees); 6. SND (degrees); 7. Distance between projections from points Go and B to the mandibular plane (GoMP-BMP) (millimeters); 8. Distance between projections from point Go and Pog to the mandibular plane (GoMP-PogMP) (millimeters); 9. Pog to NB line (Pog to NB) (millimeters); 10. Condylion to Gnathion (Co-Gn) (millimeters); 11. ANB (degrees); 12. A-B plane angle (degrees); 13. WITS appraisal (WITS) (millimeters); 14. Distance between projections from points A and B on the palatal plane (App-Bpp) (millimeters); 15. Mandibular-maxillary discrepancy (Man-Max disc) (millimeters); 16. Distance between projections from points A and B on the palatal plane (App-Pogpp) (millimeters); 17. Angle of convexity (Ang Convex) (degrees); 18. FMA (degrees); 19. Gonion to gnathion to SN (Go-Gn to SN) (degrees); 20. Angle formed by the landmarks Ar-GoX-Me (Gonial angle (Gonial ang) (degrees); 21. Lower facial height to total facial height (LFH/TFH) (ratio); 22. Posterior facial height to total facial height (PFH/TFH) (ratio); 23. Y-axis (degrees); 24. Facial axis (degrees); 25. Basion to nasion (Ba-Na) (millimeters); 26. Basion to sella (Ba-S) (millimeters); 27. Sella to nasion (S-Na) (millimeters); 28. S-Na-Ba (degrees); 29. Na-Ba-S (degrees); 30. Ba-S-Na (degrees). Dental measurements: 1. Upper incisor to sella nasion (U1 to SN) (degrees); 2. Upper incisor to palatal plane (U1 to PP) (degrees); 3. Upper incisor to A perpendicular (U1 to A Perp) (millimeters); 4. Upper incisor to A-Pogonion (U1 to A-Pog) (millimeters); 5. Upper incisor to nasion point A (U1 to NA) (degrees); 6. Upper incisor to nasion point A (U1 to NA) (millimeters); 7. Lower incisor to mandibular plane (L1 to MP) (degrees); 8. Lower incisor to A-pogonion (L1 to A-Pog) (millimeters); 9. Lower incisor to occlusal plane (L1 to OP) (degrees); 10. Lower incisor to nasion point B (L1 to NB) (degrees); 11. Lower incisor to nasion point B (L1 to NB) (millimeters); 12. Upper incisor to lower incisor (U1 to L1) (degrees); 13. Overbite (OB) (millimeters); 14. Overjet (OJ) (millimeters); 15. Upper incisor to palatal plane (U1 to PP) (millimeters); 16. Lower incisor to mandibular plane (L1 to MP) (millimeters); 17. Distance

occlusion selected from 4400 records of orthodontic patients treated during the past 8 years in the Israel Defense Forces Orthodontic Department. The cases were selected according to the clinical charts, study models, and photographs. Cases with a Class II/2 subdivision were omitted from the study.

Both the Class I control group and the Class II/1 control group were selected according to Angle criteria using the same procedure used for the experimental group. All cases were accepted after full agreement of three investigators.

The experimental Class II/2 group included 21 boys and 29 girls with a mean \pm SD age of 12.7 ± 1.6 years and an age range of 9.5 to 17.3 years. The Class I malocclusion group included 15 boys and 19 girls with a mean age of 13.6 ± 1.8 years and an age range of 9.7 to 16.7 years. The Class II/1 malocclusion group included 30 boys and 24 girls with a mean age of 12.5 ± 1.4 years and an age range of 9.7 to 15.2 years.

Cephalometric landmarks (Figure 1) were marked on each patient's lateral head film. To minimize possible errors in landmark identification, each landmark was determined by two authors (A.A. and H.M.). In cases in which a landmark identification mismatch occurred, the point was re-examined and decided on by the two other orthodontists (A.W. and N.B.). The cephalometric landmarks were later digitized. The cephalometric landmarks and measurements were calculated with an analysis program developed in the department and shown in Figure 1.

Statistics

We calculated (1) descriptive statistic for each group and (2) differences between the experimental and control groups by analysis of variance (ANOVA) with the Scheffe post hoc test. $P < .05$ was considered a statistically significant difference.

RESULTS

A comparison between the boys and girls in each group indicated no differences between the genders, so the results for both genders were pooled. There were no statistically significant differences between the ages and sex distribution in the three groups.

Tables 1 through 6 present the descriptive statistics (mean and SD) as well as the ANOVA with Scheffe post hoc test comparing the three groups. The parameters that differed significantly between the three groups are marked in the tables.

←

between projections from points U6 and PTMi on the Frankfort Horizontal plane (U6FH-PTMiFH) (millimeters).

TABLE 1. Maxillary Sagittal^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
SNA, degrees	80.8	4.0		81.1	2.9		81.5	3.5	
A to Na Perp, mm	-0.8	3.4		0.2	3.0		0.5	3.7	
Co-A, mm	90.8	4.8	3	92.8	4.8		93.6	5.2	1
ANSFH-PTMiFH, mm	55.7	4.0		57.1	2.9		57.3	3.8	

^a SNA indicates SNA angle; A, point A; Na Perp, nasion perpendicular; Co, condyion; ANSFH, point ANS to Frankfort Horizontal plane; PTMiFH, point PTMi to Frankfort Horizontal plane; and Sig, significance.

^b Numbers indicate the group(s) with significance levels $P < .05$.

TABLE 2. Mandibular Sagittal^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
SNB, degrees	77.5	3.3	3	75.9	2.7		75.3	3.3	1
SND, degrees	74.5	3.1	3	73.3	2.9		72.7	3.1	1
GoMP-BMP, mm	71.0	4.6	3	68.9	3.8		67.8	4.9	1
GoMP-PogMP, mm	76.7	4.8	3	74.9	4.4		74.1	5.0	1
Pog to NB, mm	1.3	1.5	2	2.6	1.8	1, 3	1.8	1.9	2
Co-Gn, mm	116.7	6.2		113.7	6.7		113.6	7.1	

^a SNB indicates SNB angle; SND, SND angle; GoMP, gonial point to mandibular plane; BMP, point B to mandibular plane; PogMP, pogonial point to mandibular plane; PogMP, pogonial point to mandibular plane; Pog, pogonion; NB, NB line; Co, condyion; Gn, gnathion; and Sig, significance.

^b Numbers indicate the group(s) with significance levels $P < .05$.

TABLE 3. Sagittal Jaw Relation^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
ANB, degrees	3.3	2.2	2, 3	5.2	2.2	1	6.2	2.1	1
A-B plane, degrees	-5.4	2.7	2, 3	-9.2	3.1	1	-10.4	3.3	1
WITS, mm	-0.3	2.4	2, 3	3.4	3.7	1, 3	5.6	2.7	1, 2
App-Bpp, mm	6.6	3.1	2, 3	8.9	2.7	1, 3	11.2	3.7	1, 2
Man-Max discrepancy	25.9	3.3	2, 3	20.9	5.0	1	20.0	3.8	1
App-Pogpp, mm	6.2	4.4	3	7.4	4.0	3	11.1	4.9	1, 2
Angle of convexity, degrees	5.6	5.7	3	8.2	6.1	3	11.1	5.5	1, 2

^a ANB indicates ANB angle; A, point A; B, point B; WITS, WITS appraisal; App, point A on palatal plane; Bpp, point B on palatal plane; Man-Max, mandibular-maxillary; Pogpp, pogonial point on palatal plane; and Sig, significance.

^b Numbers indicate the group(s) with significance levels $P < .05$.

TABLE 4. Vertical Skeletal^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
FMA, degrees	26.1	4.7	2	21.4	4.6	1, 3	25.1	4.8	2
Go-Gn to SN, degrees	34.3	5.1	2	30.2	4.8	1, 3	34.0	4.9	2
Gonial angle, degrees	124.3	5.6	2	120.8	6.2	1, 3	124.6	6.0	2
LFH-TFH ratio	57.2	1.7		56.2	2.5	3	57.7	2.7	2
PFH-TFH ratio	61.7	4.5	2	64.6	4.0	1, 3	61.9	3.7	2
Y-axis, degrees	59.9	3.4	2	58.0	3.1	1, 3	59.8	3.5	2
Facial axis, degrees	1.4	4.2		-0.4	3.8	3	1.8	4.4	2

^a FMA indicates FMA angle; Go, gonion; Gn, gnathion; SN, sella nasion; LFH, lower facial height; TFH, total facial height; PFH, posterior facial height; and Sig, significance.

^b Numbers indicate the group(s) with significance levels $P < .05$.

TABLE 5. Cranial Base^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
Ba-Na, mm	108.7	6.2		110.6	5.1		110.5	4.5	
Ba-S, mm	46.1	4.3		46.8	3.5		47.5	3.6	
S-Na, mm	72.8	3.9		73.7	3.1		73.1	3.2	
S-Na-Ba, degrees	18.7	2.4		18.2	2.3		18.6	2.1	
Na-Ba-S, degrees	30.3	2.6		29.5	3.0		29.4	2.7	
Ba-S-Na, degrees	131.1	4.7		132.3	5.0		132.0	4.5	

^a Ba indicates basion; Na, nasion; S, sella; and Sig, significance.
^b Numbers indicate the group(s) with significance levels $P < .05$.

TABLE 6. Dentoalveolar^a

	Class I (Group 1)			Class II/2 (Group 2)			Class II/1 (Group 3)		
	Mean	SD	Sig ^b	Mean	SD	Sig ^b	Mean	SD	Sig ^b
U1 to SN, degrees	105.7	4.0	2	90.7	6.1	1, 3	108.1	6.8	2
U1 to PP, degrees	113.9	4.6	2	99.4	5.5	1, 3	115.4	6.6	2
U1 to A Perp, mm	4.9	2.1	2	0.0	2.5	1, 3	6.1	2.5	2
U1 to A-Pog, mm	7.6	2.4	2, 3	3.6	2.5	1, 3	10.3	2.1	1, 2
U1 to NA, degrees	24.9	5.2	2	9.7	6.3	1, 3	26.6	6.8	2
U1 to NA, mm	5.3	2.5	2	0.0	2.8	1, 3	5.9	2.7	2
L1 to MP, degrees	98.6	4.8		97.4	7.4		97.7	6.4	
L1 to A-Pog, mm	3.7	2.3	2, 3	-1.1	2.3	1, 3	1.0	2.7	1, 2
L1 to OP, degrees	25.3	4.8	2	20.8	7.5	1, 3	26.0	6.1	2
L1 to NB, degrees	30.4	4.8	2, 3	23.5	6.7	1, 3	27.0	6.3	1, 2
L1 to NB, mm	6.3	2.5	2	3.2	2.4	1, 3	5.8	2.3	2
L1 to U1, degrees	121.4	7.1	2	141.6	9.7	1, 3	120.2	8.2	2
OB, mm	3.5	1.5	2, 3	6.8	2.1	1, 3	5.4	2.6	1, 2
OJ, mm	4.1	1.3	3	4.5	1.1	3	9.0	2.1	1, 2
U1 to PP, mm	29.6	2.8		29.2	3.1		29.1	3.0	
L1 to MP, mm	39.3	3.2	2	37.2	3.2	1, 3	39.3	2.9	2
U6FH-PTMiFH, mm	22.9	3.3	3	22.8	3.0		22.3	3.4	1

^a U1 indicates upper incisor; SN, sella nasion; PP, palatal plane; A Perp, point A perpendicular; A, point A; Pog, pogonion; NA, nasion point A; L1, lower incisor; MP, mandibular plane; OP, occlusal plane; NB, nasion point B; OB, overbite; OJ, overjet; U6FH, point U6 to Frankfort Horizontal plane; PTMiFH, point PTMi to Frankfort Horizontal plane; and Sig, significance.
^b Numbers indicate the group(s) with significance levels $P < .05$.

DISCUSSION

The characteristics and relative position of Class II/2 malocclusion in comparison with other malocclusions is still controversial. This controversy might be the result of the composition of each study group (mean age, age range, ethnicity, sample selection criteria, sample size, etc), the cephalometric points identified, and the types of statistical tests used. Moreover, comparative statistical tests have not been performed in all of the studies of this malocclusion and, therefore, conclusions were drawn exclusively from comparisons between the means of the experimental group vs the means of the control groups. To establish a comprehensive cephalometric characterization of the three groups, we evaluated a large number of widely used skeletal and dental cephalometric parameters.

Sagittal skeletal parameters

Sagittal skeletal parameters are shown in Tables 1 through 3. The results of this study demonstrate that the maxillary sagittal position of the three malocclusion groups is similar. This is in agreement with previously published studies.^{21,22,27-30,36,38} The tendency of a more prognathic^{17-19,38} or even retrognathic²⁰ maxilla solely related to the Class II/2 malocclusion as described in the literature was not found in this study.

The mandible in patients with Class II/2 malocclusion is described in the literature as being small^{19,21,29,31-33,36} and retrognathic^{17,20,22,27-31,36} when compared with the mandible in patients with Class I malocclusions. The results of the present study agree with these findings; however, the results did not reveal statistical significance. The Class II/2 mal-

occlusion parameters consistently had values that were between those of the Class I and Class II/1 malocclusions. This indicates that there is a general tendency for a shorter and more retrognathic mandible in Class II/2 malocclusion in comparison with Class I malocclusion and a longer and more prognathic mandible in comparison with Class II/1 malocclusion.

Other studies^{17,28,30,34} have reached similar conclusions regarding the intermediate value of the mandibular sagittal position in Class II/2 malocclusion, whereas Blair¹⁹ described a mild prognathic mandible. Renfroe¹⁷ found a comparatively longer mandible in Class II/2 malocclusion, and Kerr et al³⁴ and Kerr and Adams³⁹ found no difference in the morphology of the mandible of Class II/1 and Class II/2 malocclusions.

In the present study, the chin (Pog to NB) was found to be prominent. This is in agreement with Karlson's³¹ description of the cephalometric pattern of Class II/2 malocclusion. On the other hand, Smeets,³² Houston,²⁸ Kerr et al,³⁴ and Pancherz et al³⁶ did not find a prominent chin in their Class II/2 study group.

With respect to the intermaxillary relationship, Hitchcock³⁰ reported a statistically significant difference of the ANB angle between Class I, Class II/1, and Class II/2 malocclusions. However, this finding was not confirmed by others.³⁷ Karlson³¹ found a statistically significant difference in the ANB angle between Class I and Class II/2 malocclusions. Fischer-Brandies et al²² concluded that the A-B plane is the most reliable discriminating parameter between Class I and Class II/2 malocclusions. In the present study, the WITS appraisal and the distance between points A and B on the palatal plane (App-Bpp), both projected parameters, were the only two parameters that differentiated between all three groups with statistical significance. However, when pogonion was used as the mandibular anterior landmark (App to pogonion on the palatal plane[Pogpp] and angle of convexity), there was no statistically significant difference between the Class II/2 and Class I groups. This could explain why some researchers^{22,35,40-42} have described Class II/2 malocclusion as having a normal skeletal pattern, focusing the problem on the dentoalveolar complex.

Figure 2 is a graphical description of sagittal parameters. It was surprising to find that all parameters but one (Pog to NB) of Class II/2 lay between those of Class I and Class II/1.

Vertical skeletal parameters

The differences in the vertical dimension between the Class II/2 group and the two control groups were conclusive. The numbers (Table 4) and the graphical depiction (Figure 3) clarify this statement. The vertical characteristics of Class II/2 malocclusion include a flat mandibular plane, an acute gonial angle, an enlarged posterior facial height,

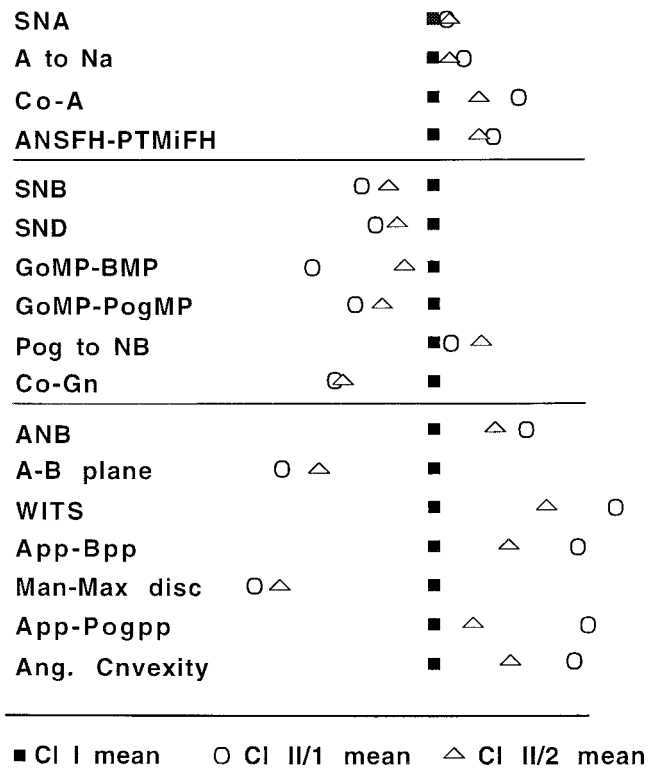


FIGURE 2. Graphical demonstration of the sagittal relationships.

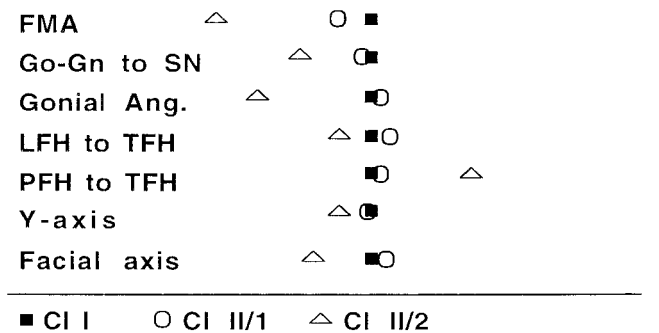


FIGURE 3. Graphical demonstration of the vertical relationships.

a reduced anterior facial height, and a more horizontal growth vector as indicated by the Downs Y-axis and Ricketts facial axis. The preceding list describes a definite hypodivergent facial pattern in the Class II/2 malocclusion group. A review of the literature reveals a wide agreement regarding the enlarged posterior facial height in Class II/2 malocclusion.^{17,25,33} As for the inclination of the mandibular plane, several studies,^{18,19,28,33} are in agreement with the present one, indicating a low mandibular plane angle in Class II/2, whereas other studies^{21,22,29,32,34,36} did not find a statistically significant difference between Class II/2 and Class I malocclusions.

Godiawala and Joshi,²¹ Fischer-Brandies et al,²² and Kerr et al³⁴ did not find statistically significant differences in the gonial angle between Class II/2 and Class I malocclusions.

Ba-Na	■ ↻
Ba-S	■ △ ○
S-Na	■ ○ ↻
S-Na-Ba	↻
Na-Ba-S	↻ ■
Ba-S-Na	■ ○ ↻

■ CI I mean ○ CI II/1 mean △ CI II/2 mean

FIGURE 4. Graphical demonstration of the cranial base relationships.

The present study, as well as those of Blair¹⁹ and Wallis,³³ found a more acute angle in Class II/2 malocclusion in comparison with Class I and Class II/1 malocclusions. Renfro¹⁷ described a more acute gonial angle in both Class II groups as compared with a Class I group.

Anterior cranial base

Houston²⁸ described a longer anterior cranial base in both divisions of Class II malocclusion as compared with Class I malocclusion. This finding led him to theorize that in Class II malocclusions, the retrognathic position of the mandible is caused by a more posterior articulation of the condyle. Wallis³³ also found a longer anterior cranial base and a more obtuse cranial base angle in Class II/2 malocclusion. In the present study, although no statistically significant difference was found between the three malocclusion groups regarding the length and the angles of the cranial base, the tendency for larger length exists (Table 5 and Figure 4).

Dentoalveolar parameters

Angle's³ original definition of Class II/2 malocclusion is based solely on dentoalveolar criteria. Therefore, it is not surprising to find broad agreement in the literature regarding the most evident dentoalveolar cephalometric characteristics of this malocclusion, such as a pronounced retroclination of the upper central incisors,* an obtuse interincisal angle,^{22,27,31,37} and a deep overbite.^{20,27,30,33,43} These findings are in full agreement with the results of the present study (Table 6). With regard to the lower incisors, numerous studies have described these incisors as having a retroclined position,^{20,27,29,32,34,43} whereas other studies^{21,36,37} have found them to have a normal inclination. In this study we found both, retroclination to the facial plane and in normal position to the mandibular plane. These results may explain the apparently contradictory results published in the literature.

The results of the present study demonstrate a normal vertical position of the upper central incisors relative to the

palatal plane. This is in agreement with the findings of other researchers.^{27,29,32} All of these studies have also described a normal vertical position of the lower incisors relative to the mandibular plane. We found that the lower incisor to mandibular plane (L1 to MP) distance was relatively short. This finding was rather surprising, since one of the dentoalveolar characteristics of Class II/2 malocclusion is a deep overbite. Deep bite is usually the result of overeruption. This might lead to a greater distance between the edges of the incisors to the palatal plane or mandibular plane, respectively. Here, although there was a deep overbite, we did not find increased distances as expected. The results of this study might suggest that the deep bite characteristic of Class II/2 malocclusion is more skeletal than dentoalveolar, with significant mandibular anterior rotation without vertical build-up compensation of the lower border of the symphysis.²³

CONCLUSIONS

Relative to Class I and Class II/1 malocclusions, Class II/2 malocclusion has the following cephalometric characteristics:

1. The maxillary length and sagittal positions are similar.
2. The mandibular length is shorter, and its sagittal position is retruded.
3. The chin is prominent.
4. The anterior-posterior jaw relationships are similar.
5. The posterior facial height is definitely enlarged.
6. The mandibular growth vector is horizontally oriented, and the mandibular plane is flat, creating the appearance of a hypodivergent facial pattern.
7. The gonial angle is acute.
8. The anterior cranial base lengths are normal.
9. Values for all Class II/2 malocclusion sagittal parameters with the exception of one parameter (Pog to NB) lie between those of Class I and Class II/1 malocclusions.
10. The upper central incisors are in pronounced retroclination.
11. The lower incisors have a normal inclination relative to the mandibular plane but are retroclined relative to various facial planes.
12. The interincisal angle is obtuse.
13. The overbite is deep, probably due to extreme skeletal mandibular counterclockwise rotation rather than dentoalveolar overeruption.
14. The overjet is normal.

Finally, we conclude that Angle Class II/2 malocclusion has not only a pathognomonic dental appearance, but also several skeletal, sagittal, and especially vertical attributes that differentiate it from both Class I and Class II/1 malocclusions.

*References 17, 20–22, 27, 29–32, 36, 37, 43.

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