Craniofacial characteristics in children with Angle Class II div. 2 malocclusion combined with extreme deep bite

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The present study deals with Angle Class II division 2 malocclusions with extreme deep bite. Epidemiologic investigations have shown that between 2% and 5% of individuals in a population have Angle Class II-2 malocclusion.[1-3] Physiognomically it may seem that patients with Angle Class II-2 often have certain common traits. Most common is perhaps a deep mento-labial sulcus over a prominent chin.

Angle Class II-2 can be associated with greatly dissimilar types of craniofacial morphology.[4] Identical occlusal types can occur in different craniofacial patterns.[5] Some researchers have even postulated that there is no clear connection between occlusal characteristics and craniofacial morphology.[6] However, there seems to be general agreement that Angle Class II-2 is characterized by normal maxillary prognathism combined with mandibular retrognathia, especially if B-point is used as a reference.[7,8] A long mental process is mentioned by some as a typical characteristic of Angle Class II-2,[9] while others have been unable to verify this.[10,11] Godiawala & Joshi[12] had a divergent finding when they determined that girls with Angle Class II-2 had normal values for both maxillary and mandibular relationships, while boys with the same type of malocclusion had a clear mandibular retrognathia when measured at B-point and the chin and compared with a normal group. According to Renfroe[13] the mandibular retrognathia with Angle Class II-2 was total, i.e. it involved not only B-point and the chin,

Abstract

Craniofacial characteristics in two groups of children were compared. In one group (n=22) the children had Angle Class II division 2 malocclusion combined with extreme deep bite. The other group (n=25) was composed of children with ideal occlusion. The mean ages of the children were 12.8 and 12.9 years respectively.

In the Class II-2 group the distance between gonion and B-point was underdeveloped, causing B-point to have a retruded position in relation to both A-point and cranial base. The Class II-2 children also had a retroclination of the symphysis, which gave the B-point a retruded position in relation to pogonion.

As for vertical dimensions, Class II-2 children had a smaller anterior lower facial height than normal. Furthermore, Class II-2 had a discrepancy between the maxillary incisal and molar heights, i.e. a slightly larger incisal height and a slightly smaller molar height. Finally, children with Class II-2 had a high lip line and a very large interincisal angle.

Three variables – the sagittal distance between points A and B, the inclination of the symphysis, and the relationship between the maxillary incisal and molar heights – in combination, differentiated nearly 100% correctly between Class II-2 and normal occlusion.

Key words

Angle Class II-2 • Deep bite • Cephalometrics • Children

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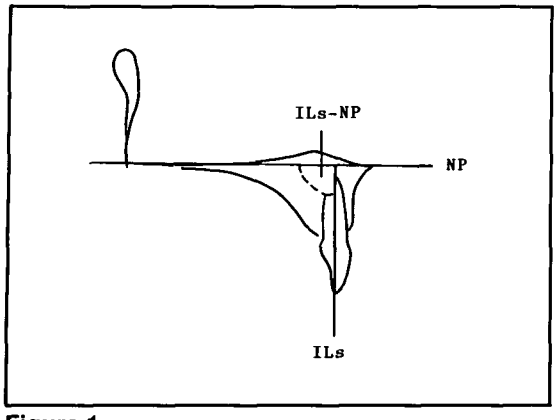

Figure 1

Figure 1
Definition of the angle ILs-NP. NP is the nasal plane and ILs the long axis of the most prominent maxillary central incisor.

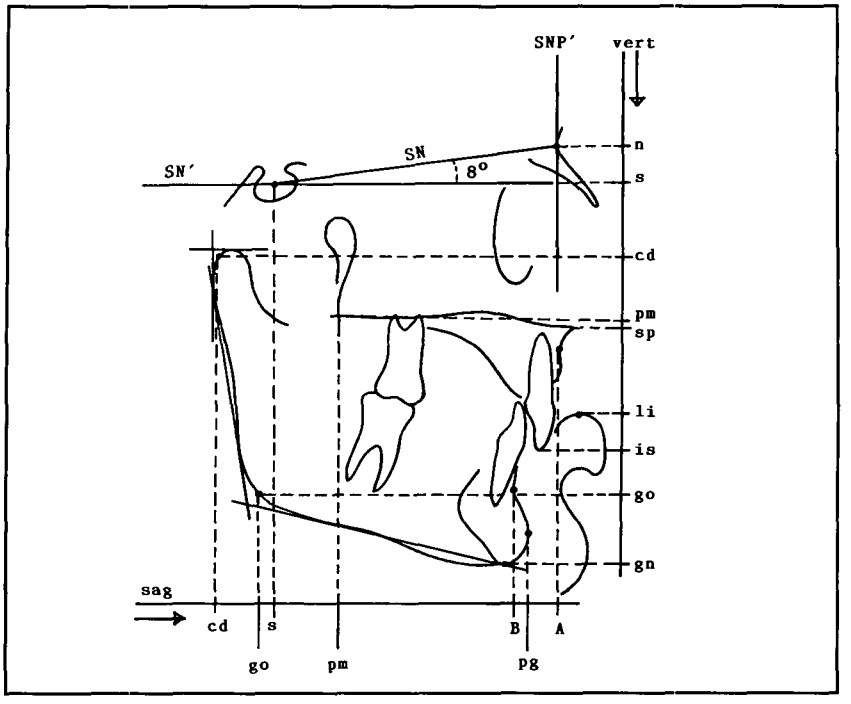

Figure 2

Figure 2
Reference points were projected on parallels to the sagittal axis SN' and the vertical axis SNP'. Sagittal distances were read from left to right, vertical distances from top to bottom (Table II, vv 1-13).

but also gonion and the condyles. Mandibular size, however, was normal. Smeets[10] and Wallis[14] found, contrary to Renfroe, that individuals with Angle Class II-2 had a short mandibular corpus. Ingervall and Lennartsson[7] could only demonstrate this characteristic in boys.

Not unexpectedly, Angle Class II-2 is also associated with deviations in the vertical relationships of the face. Among such deviations is a reduced development of the lower anterior facial height,[10] over-erupted incisors,[15] and a reduced dentoalveolar height in the molar regions.[16] Others have found normal values with Angle Class II-2 for the lower anterior facial height,[7] and the dental heights incisally[10,17] and laterally.[18] There is, however, agreement that cases with deep bite and retroclined maxillary incisors have a high lip line. Nicol[19] considered the high lip line to be an essential characteristic with this type of malocclusion and asserted that the lower lip created a retroverse plane for the maxillary incisors.

The aim of the present study was to examine the craniofacial morphology in children with Angle Class II-2 malocclusion combined with extreme deep bite.

Materials and methods

The material was selected from the Polyclinic of Orthodontics in Härnösand, Sweden, and was divided into two groups. The first group consisted of 22 children with Angle Class II-2 malocclusion. Eleven of the children had a full cusp Class II molar relationship. The remaining 11 children in this group had a strong Class II tendency with the molars occluding distally to half the width of a premolar tooth or more. The second group consisted of 25 children who, from a purely clinical perspective, had ideal occlusion according to Angle's[20] criteria. As for the Class II-2 group, criteria were attached to the vertical overbite, which was to be 8 mm or more, and the angle ILs-NP (Figure 1), which was not to exceed 95°. In comparison, Smeets[10] considered the maxillary incisors to be in retroclination if the angle mentioned was 97° or less.

Cephalometric analysis

A lateral cephalogram was taken of each child with the teeth in occlusion. Each film was traced and measured twice. Some dimensions were measured in a coordinate system with a sagittal and a vertical axis. In constructing this system, Björk's[21] mean of 82° for the angle SNA was used as a starting point. Thus, the sagittal axis was drawn through sella, 8° to SN, and referred to as SN marked (SN'). The perpendicular to SN' through nasion, in the present study referred to as SNP marked (SNP'), corresponds to the line n-A in Björk's material. From a visual standpoint this could be a logical and natural progression for the vertical axis. The sagittal axis SN', in it's course, lay near the so-called horizontal plane (HP), introduced by Burstone *et al.*[22] HP was in fact constructed through nasion, but at an angle of 7° to SN.

Figure 2 shows reference points that were projected on parallels to SN' and SNP'. Linear variables that were measured in a sagittal direction

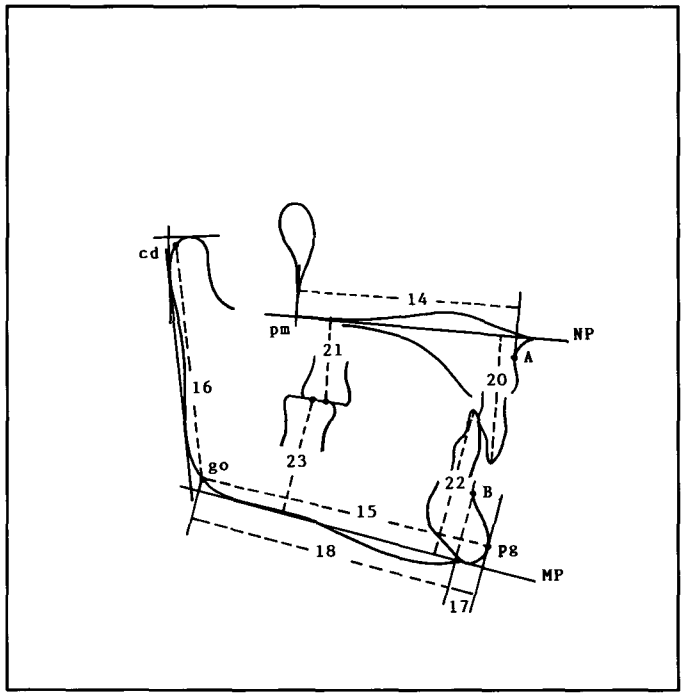

Figure 3

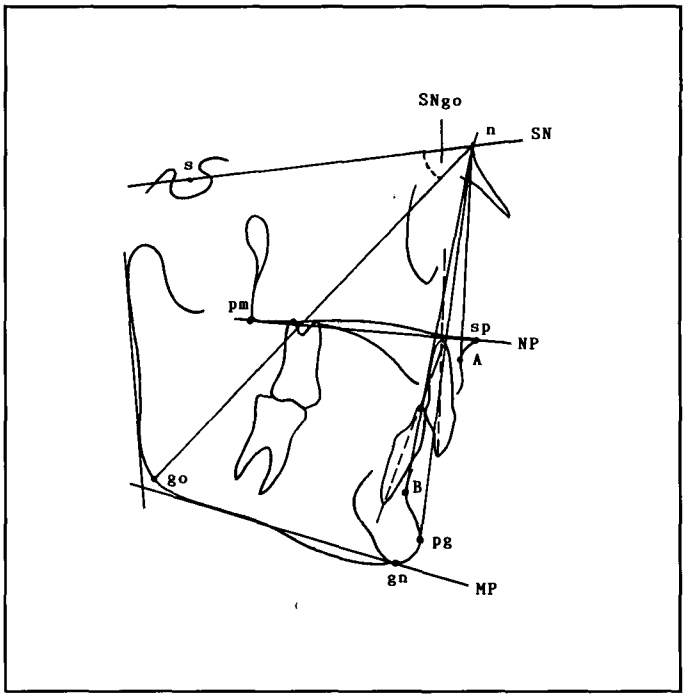

Figure 4

were marked 'sag', while those measured in a vertical direction were marked 'vert'. Figure 3 illustrates linear variables in the jaws. Points and lines used for measurement of angular variables are shown in Figure 4.

Reference points and lines are defined in Table I. Linear variables, indices and angular variables used in the study are explained in Table II.

Statistical method

Group differences were tested with Student t-test. In an attempt to find the most characteristic difference between the groups, a stepwise discriminant analysis was done. Only variables with $p<0.003$ were included prior to start. The lip line height and the interincisal angle (Table II, variables 13 and 32) were excluded from the analysis.

The discriminant analysis was done with the program 7M in the statistics package BMDP[23] and run on a VAX 6330 (Digital Equipment Corporation, Maynard, Mass.) computer at the University of Oslo. The 7M program prints out two different classification matrices, an ordinary and a so-called Jackknifed matrix. In the former, a classification formula is calculated from data from all cases, and in the latter from data from all cases except the one that is in the process of classification. The Jackknifed matrix therefore provides the most correct portrait of the classification formula's ability to classify new cases correctly.

Results

The findings are listed in Table III. In children with Class II-2 and extreme deep bite, B-point was retrognathic in relation to the cranial base (variable 27). Furthermore, a distal basal jaw relationship which was most notable with the B-point (v 1), and less clear for the chin (v 2), and a retroclined symphysis (v 4) when compared with children with normal occlusion. Children with Class II-2 had, in addition, a short distance between gonion and the B-point (v 18). The index that describes the ratio between the lengths of the maxillary and mandibular corpora exhibited a higher value with Class II-2 than with normal occlusion (v 19). In regard to the vertical dimensions of the facial cranium, the Class II-2 group had a small lower anterior facial height (v 8) and a discrepancy between the maxillary incisal and molar heights (v 24). Finally, children with Class II-2 had a higher lip line (v 13) and a much larger interincisal angle (v 32) than children with normal occlusion.

As for the discriminant analysis, the variables B-A sag (v 1), B-pg sag (v 4) and

$$\frac{NP-is-NP-U6}{NP-U6}\cdot 100$$

(v 24) proved the most effective discriminators between the groups.

In combination, the three variables differentiated correctly in 97.9% of the cases in the Jackknifed matrix (100% correct for normal occlusions and 95.5% correct for Class II-2), and in 100% of the cases in the ordinary classification matrix.

Table IV shows means and standard deviations for vertical overbite and the angle ILs-NP in the Class II-2 and normal groups. Gender distribution and age variation of the material are given in Table V. In summation, it can be said that the

Figure 3
Linear variables used for mesurement of size and proportions of the jaws. The variables are numbered according to Table II (vv 14-18 and vv 20-23).

Figure 4
Reference points and lines used for measurement of the angular variables (Table II, vv 26-32). The long axes of the incisors are stippled for clarity. A somewhat unusual angle, SNgo, is marked.

Table I
Definition of reference points and lines

Reference points (in alphabetical order)	
A-point	The deepest point on the contour of the maxillary alveolar process, measured in relation to the sagittal axis of the face (SN').
B-point	The deepest point on the contour of the mandibular alveolar process, measured in relation to the sagittal axis of the face (SN').
Condylion (cd)	Point on the contour of the condyle obtained by bisecting the angle formed by tangents to the upper and posterior borders of the condyle, the tangents being parallels to the sagittal and vertical axes of the face, respectively.
Gnathion (gn)	The deepest point of the symphysis, measured in relation to the vertical axis of the face (SNP').
Gonion (go)	Point on the contour of the mandible obtained by bisecting the angle between the mandibular plane and the tangent to the posterior border of the mandible.
Incision inferius (ii)	The incisal point of the most prominent mandibular incisor.
Incision superius (is)	The incisal point of the most prominent maxillary central incisor.
Labium inferius (li)	The highest point on the contour of the lower lip, measured in relation to the vertical axis of the face (SNP').
L6	Mid-point of the occlusal surface of the mandibular first permanent molar.
Nasion (n)	Anterior limit of the nasofrontal suture.
Pogonion (pg)	The most prominent point of the symphysis, measured in relation to the sagittal axis of the face (SN').
Pogonion marked (pg')	The most prominent point of the symphysis, measured in relation to the mandibular plane (MP).
Pterygomaxillare (prn)	Point of intersection of hard palate, soft palate and pterygopalatal fissure.
Sella (s)	Center of sella turcica.
Spinal point (sp)	Apex of the anterior nasal spine.
U6	Mid-point of the occlusal surface of the maxillary first permanent molar.
Reference lines	
SN Anterior cranial base	The line between sella and nasion.
NP Nasal plane	The line between pterygomaxillare and the spinal point.
MP Mandibular plane	The tangent to the lower border of the mandible through gnathion.
ILs	The line from incision superius through apex.
ILi	The line from incision inferius through apex.

selected Class II-2 cases had extreme deep bite. Gender distribution in the material was fairly even. Age variation was great, though more or less the same for the two groups.

Discussion

The clear distal relationship between points A and B in children with Class II-2 is not surprising in light of earlier studies.[7,8] That the same children also had a somewhat less clear distal relationship between A-point and chin (v 2), is not quite unexpected either.[7,8]

The maxillary prognathism, measured at the A-point, was approximately the same in the two groups, as was gonion's sagittal position. Neither was there any significant difference between the groups in the inclination of the mandibular plane. The Class II-2 group, however, stood out in that the distance between gonion and the B-point was, on the average, approximately 4 mm shorter than

Table II
Definition of variables

Variables measured along the sagittal axis (Figure 2)

Sagittal jaw relationships

1. B-A sag — Sagittal distance between points A and B.
2. pg-A sag — Sagittal distance between pogonion and A-point.
3. go-pm sag — Sagittal distance between posterior borders of the mandibular and maxillary corpora.

Inclination of the symphysis

4. B-pg sag — Sagittal distance between B-point and pogonion.

Sagittal position of condyles

5. cd-s sag — Sagittal distance between condylion and sella.

Variables measured along the vertical axis (Figure 2)

Facial heights

6. n-gn vert — Anterior facial height.
7. n-sp vert — Upper anterior facial height.
8. sp-gn vert — Lower anterior facial height.
9. s-go vert — Posterior facial height.
10. s-pm vert — Upper posterior facial height.
11. pm-go vert — Lower posterior facial height.

Vertical position of condyles

12. s-cd vert — Vertical distance between sella and condylion.

Height of the lip line

13. li-is vert — Vertical distance between labium inferius and incision superius.

Size of jaws (Figure 3)

Basal bone

14. pm-A — Distance between pterygomaxillare and A-point, measured along the nasal plane (NP). Length of maxillary corpus.
15. go-pg' — Length of mandibular corpus.
16. cd-go — Height of mandibular ramus.
17. B-pg' — Distance between B-point and pogonion marked, measured along the mandibular plane (MP). Length of mental process.
18. go-B — Distance between gonion and B-point, measured along the mandibular plane (MP). Lenght of mandibular corpus minus mental process.
19. $\frac{pm - A}{go - pg'} \cdot 100$ — Ratio between the lengths of the maxillary and mandibular corpora.

Dental heights

20. NP-is — Distance between incision superius and the nasal plane (NP), measured along a perpendicular to NP. Maxillary incisal height.
21. NP-U6 — Distance between point U6 and the nasal plane (NP), measured along a perpendicular to NP. Maxillary molar height.
22. ii-MP — Distance between incision inferius and the mandibular plane (MP), measured along a perpendicular to MP. Mandibular incisal height.
23. L6-MP — Distance between point L6 and the mandibular plane (MP), measured along a perpendicular to MP. Mandibular molar height.
24. $\frac{NP - is - NP - U6}{NP - U6} \cdot 100$ — Difference between maxillary incisal and molar heights, measured in relation to the maxillary molar height.
25. $\frac{ii - MP - L6 - MP}{L6 - MP} \cdot 100$ — Difference between mandibular incisal and molar heights, measured in relation to the mandibular molar height.

Angles (Figure 4)

26. SNA — Maxillary prognathy.
27. SNB — A measurement of mandibular prognathy.
28. SNpg — A measurement of mandibular prognathy.
29. SNgo — Sagittal position of gonion in relation to the anterior cranial base.
30. NP-SN — Nasal plane angle.
31. MP-SN — Mandibular plane angle.
32. ILs-ILi — Interincisal angle.

Table III
Mean and standard deviation for significantly different (p<0.003) variables in Class II-2 and normal occlusion

Variables	Class II-2 (n=22)		Normal Occlusion (n=25)		
	Mean	S.D.	Mean	S.D.	p-value
Linear (mm)					
1. B-A sag	8.60	2.41	3.88	2.25	0.0000
2. pg-A sag	5.28	2.96	2.45	3.16	0.0027
4. B-pg sag	3.37	1.31	1.41	1.25	0.0000
8. sp-gn vert	56.43	4.14	60.31	4.21	0.0027
13. li-is vert	7.76	1.51	3.47	1.04	0.0000
18. go-B	65.01	4.18	68.81	4.04	0.0029
Indices					
19. $\frac{pm-A}{go-pg'}\cdot 100$	70.10	4.24	64.92	4.14	0.0001
24. $\frac{NP-is-NP-U6}{Np-U6}\cdot 100$	34.43	9.47	21.47	9.44	0.0000
Angles (°)					
27. SNB	77.78	3.14	80.80	2.98	0.0016
32. ILs-ILi	160.51	6.45	126.93	8.10	0.0000

in the normal group (v 18). This deviation was probably the primary contributor to the mandibular retrognathism of the Class II-2 group, measured at the B-point (v 27), and to the group's clear distal relationship between points A and B (v 1).

The Class II-2 group's somewhat less clear distal relationship between A-point and chin (v 2) must be explained in another way. The average values show that with Class II-2 there was a tendency towards a slightly long corpus maxillae and a slightly short corpus mandibulae. This was expressed in the index which presents the size relationship between the corpora of the jaws (v 19). The two tendencies probably functioned synergistically, not only on the value of the index, but also on the group difference for the sagittal distance between A-point and chin.

The tendency towards a short mandibular corpus in children with Class II-2 is due to the short go-B distance in these children. It is true that the Class II-2 group also had a tendency towards overdevelopment of the mental process, but this could not support the clear underdevelopment of the remaining portion of the corpus.

As mentioned in the introduction, Renfroe[13] postulated that the mandibular retrognathism with Angle Class II-2 was total, that is to say it incorporated the entire mandible. The present findings point in another direction, as the children with Class II-2 had normal positions of the condyles and gonion in relation to the cranial base. The mandibular retrognathism involved only the anterior portion of the lower jaw (v 27). This pattern resembles the pattern with Angle Class II-1, as described by Craig.[24]

It was probably the distal relationship between the anterior parts of the jaws (vv 1, 2) that restricted children with Class II-2 from establishing a stable incisal occlusion. Perhaps the distal basal relationship was also a factor in enabling the lower lip, with a high lip line (v 13) to have a strong retroversive effect on the maxillary central incisors. Such an idea would be along the same lines as Hovell,[25] who maintained that the influence of the soft-tissue morphology on the dental structures should always be evaluated in light of the underlying skeletal relationships. In children with Class II-2 the retroclined maxillary incisors led to the establishment of a large interincisal angle (v 32). This also had a negative influence on the stability of the incisal occlusion. The Class II-2 group's smallest interincisal angle (149°) was larger than the normal group's largest (143°).

The retroclination of the symphysis in children with Class II-2 caused these children to have a relatively large distance along the sagittal plane between B-point and pogonion (v 4). This created the impression that the mandibular incisors had assumed a retracted position on the mandibular corpus. The impression, however, was partially illusionary. As mentioned, there was only a tendency towards overdevelopment of the mental process with Class II-2.

As for the vertical relationships of the facial cranium, children with Class II-2 had a smaller anterior lower facial height than normal (v 8). This was as anticipated. Earlier researchers have proven underdevelopment of anterior lower facial height with both deep bite[26,27,28,29] and Class II-2 malocclusions.[10] In contrast, the present findings showed no significant group difference in mandibular plane inclination, even though there was a tendency towards a smaller MP-SN angle in children with Class II-2. The mean value for this angle was 25.8° in the Class II-2 group and 28.7° in the normal group. That the difference was not significant reflects only that Class II-2, even when combined with extreme deep bite, can occur in faces with varying mandibular plane angles. In the present study excessive deep overbite was, in one case, combined with an MP-SN angle of 37°. The present findings correspond with earlier studies which could not prove any deviation in the MP-SN angle with Angle Class II-2 malocclusions.[7,10]

Children with Class II-2 had a discrepancy between the maxillary incisal and molar heights. The mean values for the two variables show that with Class II-2 there was a tendency towards a

slightly larger than normal maxillary incisal height (ca. 1.5 mm) and a slightly smaller than normal maxillary molar height (ca. 1 mm). Here, as well, it could be a matter of two trends that synergistically affect the index value (v 24) so that a significant variation from the normal occurs. In the mandible the situation was different. With Class II-2 there was a tendency towards underdevelopment of the mandibular molar height, but the mandibular incisal height was normal.

Because of the retroclination, the Class II-2 group's maxillary incisors were positioned almost perpendicularly on the nasal plane. This probably contributed to the slight overdevelopment of the maxillary incisal height. Logan[15] suggested the same when he described deep bite that was combined with retroclined maxillary incisors. Concerning the Class II-2 group's somewhat short maxillary molar height, the present findings lead to the ideas of Isaacson *et al.*[30] who considered maxillary molar height to be morphologically causative in the development of high or low MP-SN angles and their respective growth patterns. With high angles the maxillary molar height was large, with low angles it was small. The mandibular molar height varied after the same pattern, but not as clearly. The Class II-2 group in the present study could be described as a low angle group, though not an extreme one. Although the MP-SN angle's mean value was 25.8°, the standard deviation was 5°. In comparison, the corresponding values in the material of Isaacson *et al.* were 22.5° and 2.2°.

The somewhat large maxillary incisal height and small maxillary molar height with Class II-2 can also be seen in light of implant studies by Björk & Skieller.[31] According to these studies the incisal occlusion could affect not only the mandibular rotation pattern but also the development of dentoalveolar height. Thus, if the incisal occlusion was stable, the mandible would rotate anteriorly on a center with the mandibular incisors. At the same time there would be a differentiated eruption of the incisors and molars of both jaws, in which the molars would erupt more than the incisors as compensation for the jaw rotation. If, however, the incisal occlusion was unstable, a skeletal deep bite could develop. The center for the anterior mandibular rotation did not then lie with the mandibular incisors, but farther back with the premolars. In such cases a differentiated eruption of the incisors and molars would not occur. As an example of development of this type, the authors referred to an Angle Class II-2 case with extreme deep bite where the vertical overbite had increased by 4 mm from 12 to 18 years of age.

Table IV
Mean and standard deviation for vertical overbite (mm) and the angle ILs-NP in the Class II-2 and normal groups

	n	Vertical overbite	ILs-NP
Class II-2	22	9.67 ± 1.20	90.07 ± 4.30
Normal	25	3.07 ± 0.69	113.49 ± 4.75

Table V
Gender distribution and age variation in the Class II-2 and normal groups.

	n	Boys	Girls	Average age Total	Boys	Girls	Youngest	Oldest
Class II-2	22	11	11	12.8 yr	12.6 yr	13.0 yr	10.8 yr	15.3 yr
Normal	25	12	13	12.9 yr	12.9 yr	12.8 yr	10.7 yr	14.7 yr

The present study is cross-sectional and does not provide a basis for the evaluation of causal factors in Class II-2 and deep bite. Nonetheless, the findings can invite purely theoretical conclusions on the subject. With reference to this, the Class II-2 group's partial underdevelopment of corpus mandibulae (the short distance go-B) is interesting because it probably was influential in that children in the group did not establish stable incisal occlusion. As shown in the previously mentioned implant studies, this could have opened the way for an anomalous mandibular rotation and development of a skeletal deep bite. With Class II-2 the anterior lower facial height was underdeveloped and the symphysis retroclined. Both conditions are to be expected if the mandible rotates anteriorly on a center posterior to the mandibular incisors.

Conclusions

The sagittal group differences were limited to the mandibular corpus and the chin region. In the Class II-2 group the distance between gonion and the B-point was underdeveloped. Primarily as a result of this, the group's B-point had a retruded position in relation to both the A-point and the cranial base. With Class II-2 the symphysis had a retroclined position in the face. This caused the B-point to also have a retruded position in relation to pogonion.

The only skeletal group difference in a vertical direction involved the anterior lower facial height, which was underdeveloped with Class II-2. Re-

garding the development of the dentoalveolar dimensions, the Class II-2 group had a discrepancy between the maxillary incisal and molar heights, that is to say a slightly large incisal height and a slightly small molar height. Finally, the Class II-2 group differentiated itself with a higher lip line and a much larger interincisal angle than normal.

Discriminant analysis showed that three variables – the sagittal distance between points A and B, the inclination of the symphysis, and the relationship between the maxillary incisal and molar heights – in combination, differentiated nearly 100% correctly between Class II-2 and normal occlusion.

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