Cephalometric characteristics of Class II division 1 and Class II division 2 malocclusions: A comparative study in children

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In dentofacial orthopedics a thorough knowledge of the skeletal and dental components that contribute to a particular malocclusion is essential because these elements may influence the approach to treatment.

The dentoskeletal morphology of Class II malocclusion has been analyzed in a number of cephalometric investigations.[1-22] The value of these studies is limited, however, by the following factors: (1) No clear definition of Class II malocclusion; the demarcation between Class II and Class I, especially in the mixed dentition, is vague;[18] (2) No differentiation between Class II division 1 and Class II division 2 cases;[18,22] such a differentiation is most important, as division 2 subjects may have a specific craniofacial morphology;[23-31] (3) Insufficient sample size; this is especially true when evaluating Class II division 2 malocclusions. Furthermore, the influence of maturation (age) on the dentoskeletal morphology has been neglected in most of the studies.

The aim of the present cephalometric roentgenographic study was to compare large samples of well defined Class II division 1 and Class II division 2 malocclusions. Children at the ages of 8-10 years and 11-13 years were evaluated.

Materials and methods

The patient files of three university orthodontic departments, (Giessen and Marburg in Germany and Malmö in Sweden), as well as of two private orthodontic practices (in Wiesbaden and Frankfurt, Germany) were screened. All Class II division 1 (n=347) and division 2 (n=156) sub-

Abstract

A comparison of dentoskeletal morphology in 347 Class II division 1 and 156 Class II division 2 malocclusions was performed using lateral cephalometric radiographs. Children at the ages of 8-10 years and 11-13 years were evaluated. The results of the study revealed broad variations in the variables analyzed. Skeletal Class II and Class III as well as hypo- and hyperdivergent maxillary/mandibular jaw base relationships were seen in both malocclusion samples. Noteworthy was the high frequency of cases with mandibular retrusion (Class II division 1 sample: 48% of the younger and 29% of the older subjects; Class II division 2 sample : 48% of the younger and 49% of the older subjects) and a short lower face (97% - 100%). In conclusion it can be said that, except for the position of the maxillary incisors, no basic difference in dentoskeletal morphology exists between Class II division 1 and Class II division 2 malocclusions.

Key Words

Class II division 1 malocclusion • Class II division 2 malocclusion • Roentgenographic cephalometry • Dentoskeletal morphology • Age groups

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Table 1
Distribution of 347 Class II division 1 and 156 Class II division 2 subjects

Subjects	Class II, 1		Class II, 2	
	8-10 yrs	11-13 yrs	8-10 yrs	11-13 yrs
Males	114	58	54	33
Females	124	49	32	37
Total	240	107	86	70

Table 2
Digitizing (ME-dig) and total (ME-tot) errors in the evaluation of Class II division 1 (examiner BH) and Class II division 2 (examiner KH) malocclusions

Variables	Class II div 1		Class II div 2	
	ME-dig	ME-tot	ME-dig	ME-tot
SNA	0.16	0.97	0.13	0.64
SNB	0.15	0.87	0.10	0.52
SNPg	0.15	0.88	0.11	0.47
ANB	0.07	0.37	0.08	0.32
ANPg	0.09	0.29	0.10	0.33
ML/NSL	0.15	1.05	0.15	0.57
NL/ML	0.14	0.71	0.20	0.56
FH Index	0.11	0.55	0.09	0.32
U1/NL	0.27	1.30	0.22	1.67
L1/ML	0.33	1.46	0.42	1.32

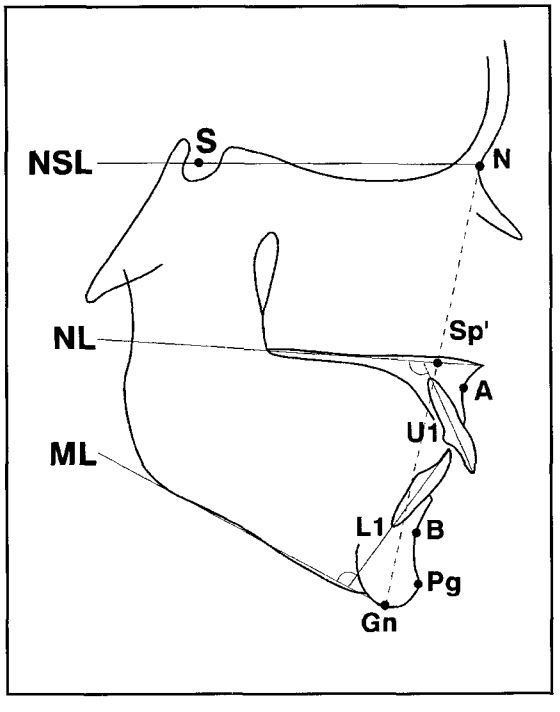

Figure 1
Reference points and lines used in the cephalometric analysis.

jects who were between 8 and 13 years old and who fulfilled the following requirements (as determined on pretreatment dental casts) were selected:

1. Bilateral distal molar relationships of more than one-half cusp width when the deciduous lower second molars were still present. (This applied to both Class II division 1 and Class II division II cases.)
2. Bilateral distal molar and canine relationships of at least one-half cusp width when the permanent teeth in the lateral segments had erupted. (This applied to both division 1 and division 2 cases.)
3. Proclination of the maxillary front teeth with an overjet of more than 5 mm (Class II division 1 cases only).
4. Retroclination of the maxillary front teeth (at least of the two central incisors) and deepbite (Class II division 2 cases only).

While subject selection was based on the analysis of pretreatment dental casts, dentoskeletal morphology was assessed on pretreatment cephalometric roentgenograms. Subjects were divided into two age groups: 8-10 years and 11-13 years. Distribution of the subject material is seen in Table 1.

In the evaluation of dentoskeletal morphology in the two malocclusion samples, reference data from two cephalometric standards, the Michigan data[32] and the London data,[33] were used for comparison.

All measurements on the profile roentgenograms were performed on matte acetate tracing film. Reference points were marked with a finely-sharpened All-Stabilo pencil (Schwan-Stabilo, Germany). Points were transferred from the tracings to a computer using the Scriptel digitizer (Scriptel Corp, Columbus, Ohio, USA). The evaluation was done with the Dentofacial Planner 5.3 (Gemetek, Erding, Germany). All linear measures were corrected for radiographic enlargement ranging from 7% to 11%.

The reference points and lines used are shown in Figure 1. The cephalometric analysis comprised the following variables:

Sagittal jaw position and jaw relation

1. Maxillary position (SNA)
2. Mandibular position (SNB)
3. Mandibular position (SNPg)
4. Maxillary/mandibular relation (ANB)
5. Maxillary/mandibular relation (ANPg)

Vertical jaw position and jaw relation

6. Mandibular plane angle (ML/NSL)
7. Maxillary/mandibular relation (NL/ML)
8. Facial height (FH) index: (Sp´ - Gn/N - Gn) x 100

Table 3
Cephalometric records describing dentoskeletal morphology in 347 Class II division 1 and 156 Class II division 2 malocclusions. Subjects were divided into two groups: younger, 8-10 years old, and older, 11-13 years. Statistical difference (D) between malocclusions, as well as age, was assessed

Variables	Age Years	Class II div 1 Mean	SD	Age (D)	Class II div 2 Mean	SD	Age (D)	Class II div 1/2 (D)
SNA	8-10	79.4	3.4	n.s.	78.3	2.8	n.s.	**
	11-13	80.0	3.5		78.9	3.1		*
SNB	8-10	73.4	3.1	***	73.2	2.7	n.s.	n.s.
	11-13	74.7	3.3		73.7	2.7		*
SNPg	8-10	74.3	3.1	***	74.7	2.9	n.s.	n.s.
	11-13	75.8	3.6		75.2	2.8		n.s.
ANB	8-10	6.0	1.9	***	5.1	1.9	n.s.	**
	11.13	5.3	2.1		5.2	2.0		n.s.
ANPg	8-10	5.1	2.3	***	3.6	2.4	n.s.	***
	11-13	4.2	2.6		3.7	2.3		n.s.
ML/NSL	8-10	34.6	4.9	**	32.7	4.5	n.s.	**
	11-13	33.2	5.5		33.0	6.0		n.s.
NL/ML	8-10	25.9	4.8	n.s.	22.3	4.3	n.s.	***
	11-13	24.9	5.3		22.3	6.1		**
FH Index	8-10	45.8	2.0	n.s.	47.0	1.8	n.s.	***
	11-13	46.0	2.0		47.0	2.1		***
U1/NL	8-10	114.5	6.1	n.s.	93.1	6.5	n.s.	***
	11-13	114.3	6.7		93.0	5.2		***
L1/ML	8-10	97.8	6.1	n.s.	90.5	5.2	n.s.	***
	11-13	98.4	7.4		89.9	7.4		***

Significance level: *5%; **1%; ***0.1%; n.s. not significant

Tooth position

9. Upper incisor position (U1/NL)
10. Lower incisor position (L1/ML)

Statistical methods

All statistical calculations were performed with the program Microsoft Excel 4.0. In the presentation of the results, the arithmetic mean (Mean), standard deviation (SD), maximum (Max), and minimum (Min) are given for each cephalometric variable. Unpaired *t*-tests were performed to assess differences between malocclusion groups as well as between age and gender groups. The levels of significance used were $P < 0.001$ (***), $P < 0.01$ (**) and $P < 0.05$ (*). $P \geq 0.05$ was considered not significant (n.s.).

Method error

A single examiner performed all the registrations for one malocclusion sample. (BH analyzed the division 1 subjects and KZ analyzed the division 2 subjects). Radiographs of 20 cases randomly selected from each malocclusion group were traced and digitized a second time after an interval of several days. The method error (ME) for each variable was calculated using the formula: $ME = \sqrt{\frac{\sum d^2}{2n}}$ where d is the difference between two registrations of a pair and n is the number of duplicate registrations. The digitizing error (ME-dig) and the total error (ME-tot) comprising both the tracing and digitizing errors were calculated. The results are seen in Table 2.

Results

When comparing males and females in the two malocclusion samples as well as the two age groups, no statistically significant differences were found for any of the variables. Therefore, with respect to gender, the samples were pooled.

The records of the skeletal and dental variables describing the morphology of the Class II division 1 and Class II division 2 malocclusions are shown in Table 3 and Figures 2-11.

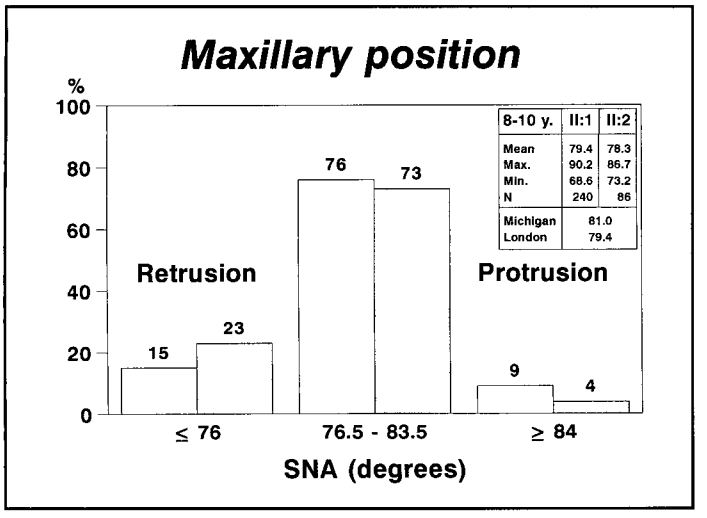

Figure 2A

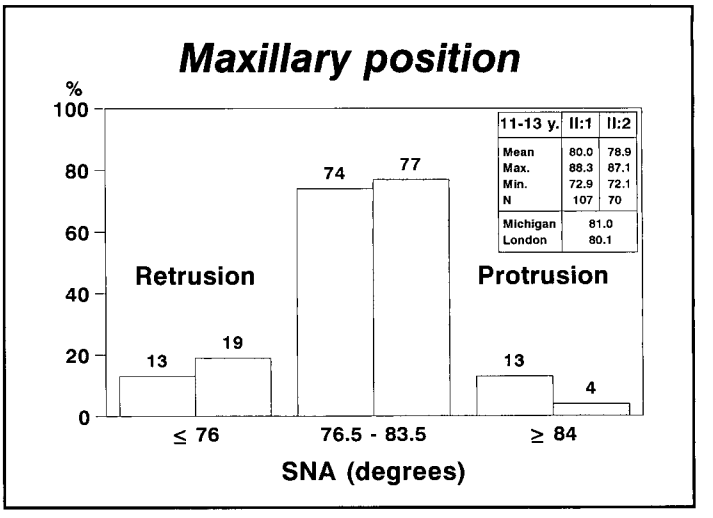

Figure 2B

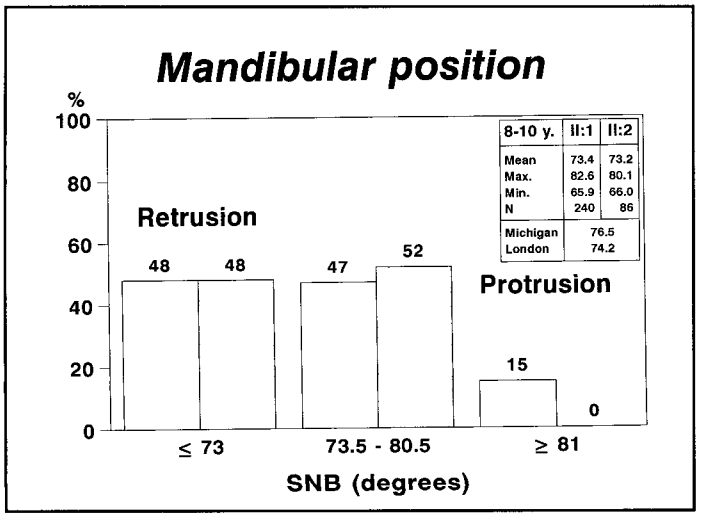

Figure 3A

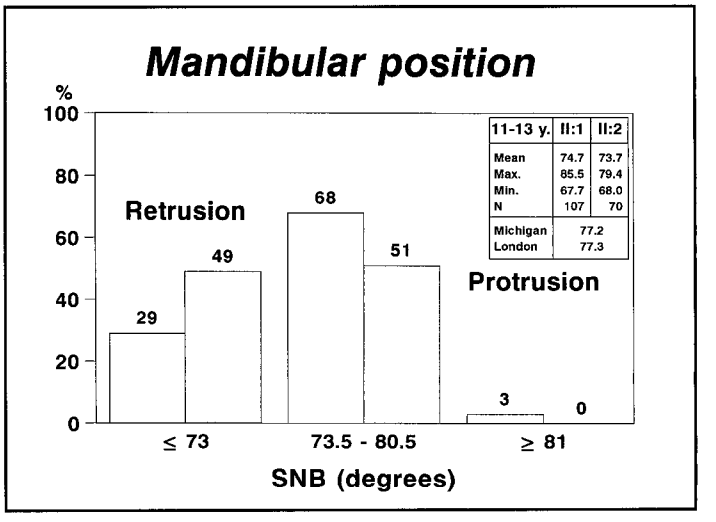

Figure 3B

Figure 2A-B
Distribution of the SNA angle in Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Figure 3A-B
Distribution of the SNB angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Sagittal maxillary position (SNA)

Compared with the Michigan[32] and London[33] reference data, the SNA angle was, on average, smaller in both the division 1 and division 2 samples (Figure 2). SNA was also smaller in both age groups of the division 2 sample than in the division 1 (Table 3) and the frequency of subjects with maxillary retrusion was higher (Figure 2). No age differences were found for SNA (Table 3) or for the frequency of subjects with maxillary retrusion (Figure 2) between the samples.

Sagittal mandibular position (SNB, SNPg)

Compared with the Michigan[32] and London[33] reference data, the SNB and SNPg angles were, on average, smaller in both malocclusion samples (Figures 3 and 4). In the older groups, SNB was smaller in the division 2 sample than in the division 1 (Table 3) and the frequency of subjects with mandibular retrusion was higher (Figure 3B). In the younger groups, no differences (SNB angle, frequency of subjects with mandibular retrusion) were found between the two malocclusion samples (Table 3, Figure 3A). SNB angle was smaller in the Class II division 1 sample than in the division 2 group (Table 3) and the frequency of subjects with mandibular retrusion was higher (Figure 3) in the younger group. In the division 2 group, no age differences were found (Table 3, Figure 4).

When using the SNPg angle to evaluate sagittal mandibular position, a pattern similar to that of SNB was found (Table 3, Figure 4).

Sagittal maxillary/mandibular relationship (ANB, ANPg)

Compared with the Michigan[32] and London[33] reference data, the ANB and ANPg angles were, on average, greater in both malocclusion samples (Figures 5 and 6). ANB was larger in the younger group in the division 1 sample (Table 3) and the frequency of subjects with skeletal Class II relationships was higher (Figure 5). In the older group, no differences (ANB angle, frequency of

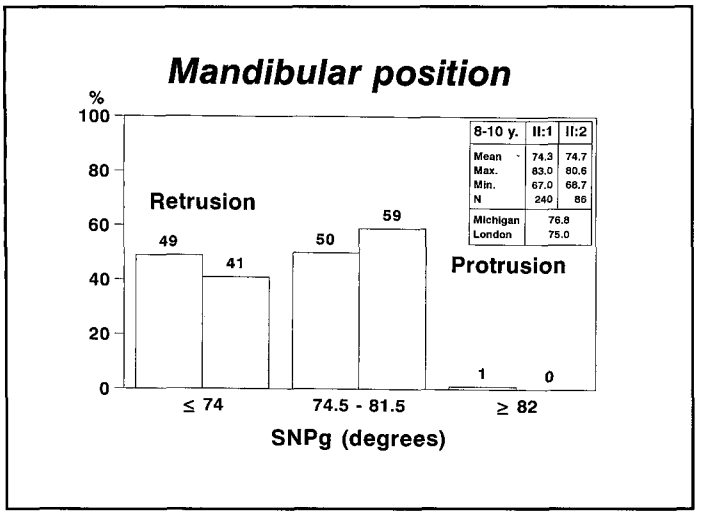

Figure 4A

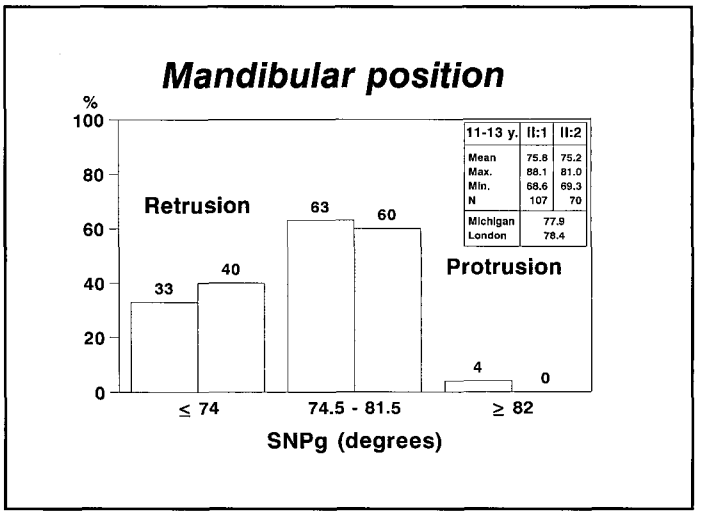

Figure 4B

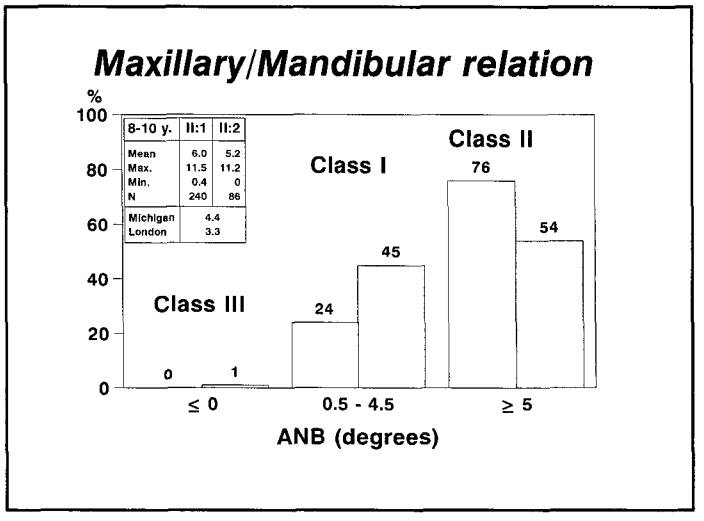

Figure 5A

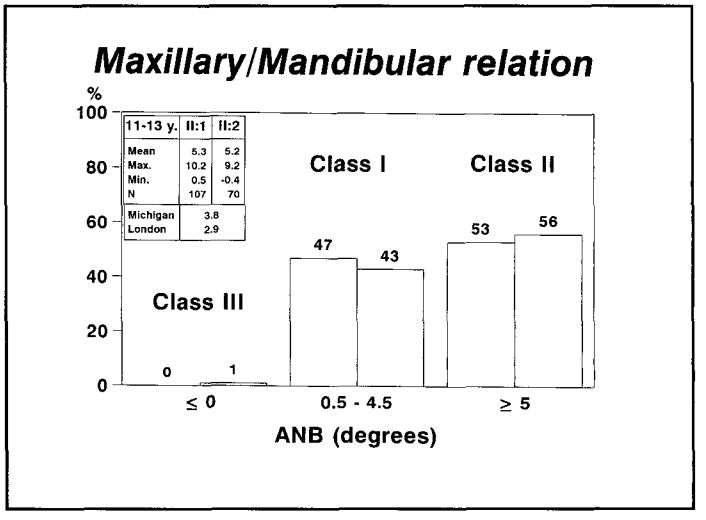

Figure 5B

subjects with skeletal Class II relationships) were found between malocclusion samples (Table 3, Figure 5B).

No age differences were found in the Class II division 2 sample (Table 3, Figure 5).

When using the ANPg angle to evaluate maxillary/mandibular relationships, a pattern similar to that of ANB was found (Table 3, Figure 6).

Mandibular plane angle (ML/NSL)

Compared with the Michigan[32] and London[33] reference data, the ML/NSL angle was, on average, smaller in both malocclusion samples (Figure 7). In the division 2 sample, ML/NSL was smaller (Table 3) and the frequency of low angle subjects was higher (Figure 7A) in the younger group than in the older one. The opposite was true with respect to the frequency of high angle subjects. No differences (ML/NSL angle, frequency of high and low angle subjects) between the malocclusion samples were found in the older age group (Table 3, Figure 7B).

In the Class II division 1 sample, ML/NSL was smaller (Table 3) and the frequency of low angle subjects was higher (Figure 7) in the older group. No age difference was found for the frequency of high angle subjects. In the division 2 sample, ML/NSL was comparable (Table 2) in the older and younger groups while the frequency of low and high angle subjects was higher (Figure 7) in the older group.

Vertical maxillary/mandibular relation (NL/ML)

Compared with the Michigan[32] and London[33] reference data, the NL/ML angle was, on average, smaller in both malocclusion samples (Figure 8). In the division 2 sample, NL/ML was smaller in both age groups (Table 3) and the frequency of hypodivergent subjects was higher (Figure 8) than in the division 1 sample. In neither of the two malocclusion samples was an age difference found for NL/ML (Table 3) or for the frequency of hypodivergent subjects (Figure 8).

Figure 4A-B
Distribution of the SNPg angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Figure 5A-B
Distribution of the ANB angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

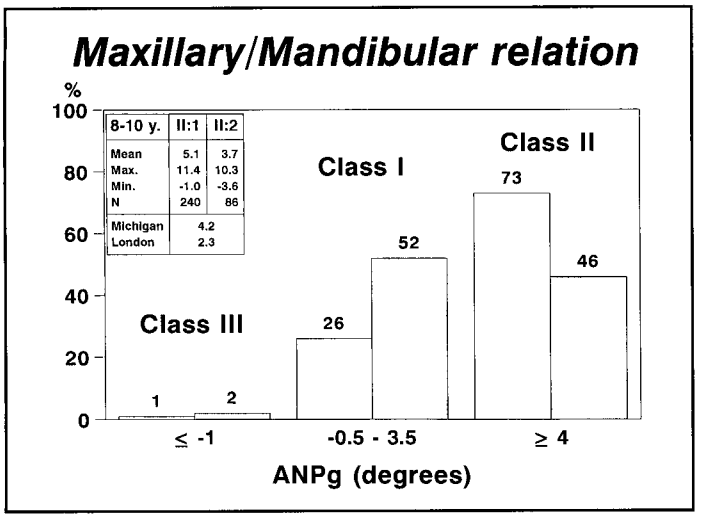

Figure 6A

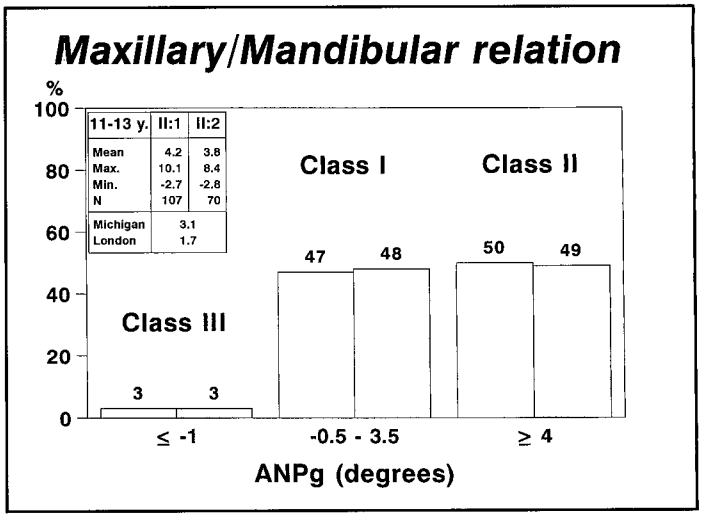

Figure 6B

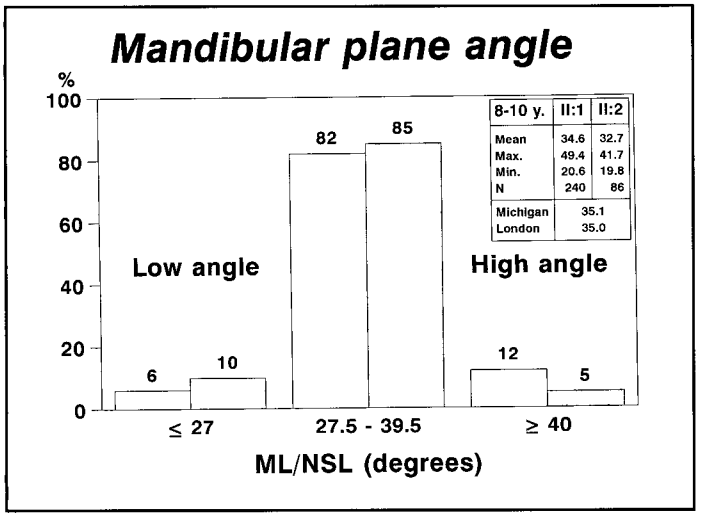

Figure 7A

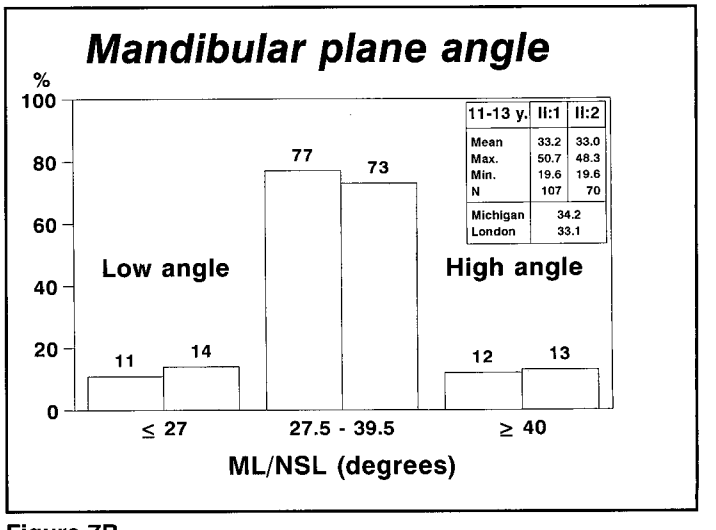

Figure 7B

Figure 6A-B
Distribution of the ANPg angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Figure 7A-B
Distribution of the ML/NSL angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Facial height (FH) index: (Sp´-Gn/N-Gn) x 100

Compared with the London[33] reference data, the FH index was, on average, smaller in both malocclusion samples (Figure 9) The index was smaller for both age groups (Table 3) in the division 1 sample than in the division 2 sample. A short lower face existed in all division 1 and almost all division 2 subjects (Figure 9). In neither of the two malocclusion samples was an age difference found for the FH index (Table 3) or for the frequency of subjects with a short lower face (Figure 9). Long lower face height did not exist in any of the subjects in either of the malocclusion samples.

Upper incisor position (U1/NL)

Due to the method of case selection it was natural that, compared with the Michigan[32] and London[33] reference data, the U1/NL angle was, on average, larger in the division 1 sample and smaller in the division 2 (Figure 10).

However, in the division 1 sample, only 18% of the younger and 20% of the older subjects exhibited proclined maxillary incisors in accordance with the cephalometric definition (Figure 10). In the division 2 sample, on the other hand, 100% of the older and 99% of the younger subjects showed retroclined incisors in accordance with the cephalometric definition (Figure 10).

Lower incisor position (L1/ML)

Compared with the Michigan[32] and London[33] reference data the L1/ML angle was, on average, larger in the division 1 sample and smaller in the division 2 (Figure 11).

In the division 1 sample, incisor proclination was present in about 50% of the subjects in each age group while incisor retroclination was seen in very few of the cases (0% - 3%). In the division 2 sample, incisor proclination and retroclination occurred at about the same frequency (7% - 11%) in the two age groups (Figure 11).

In neither of the two malocclusion samples was

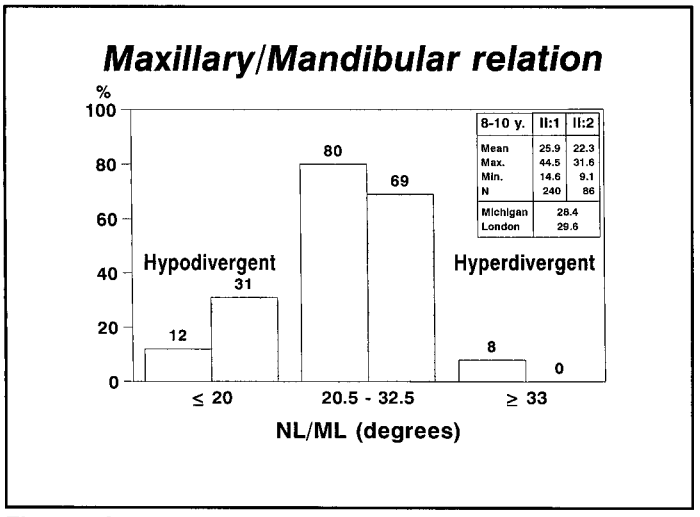

Figure 8A

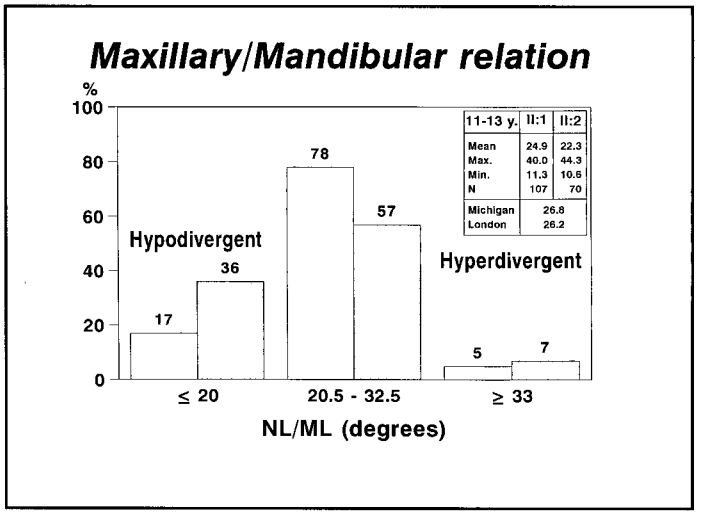

Figure 8B

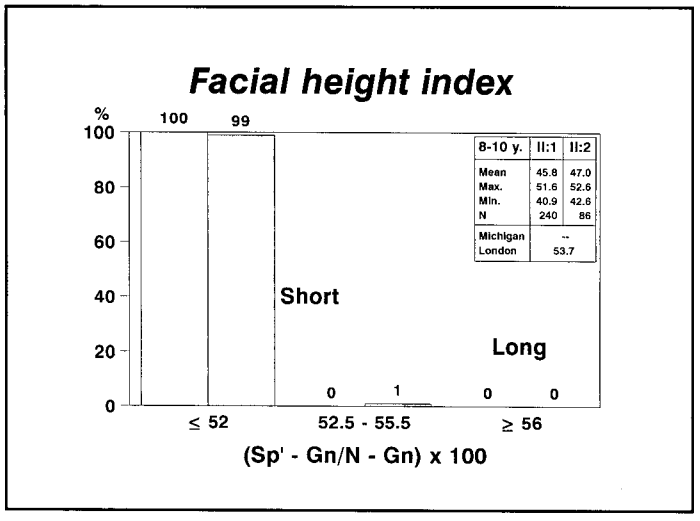

Figure 9A

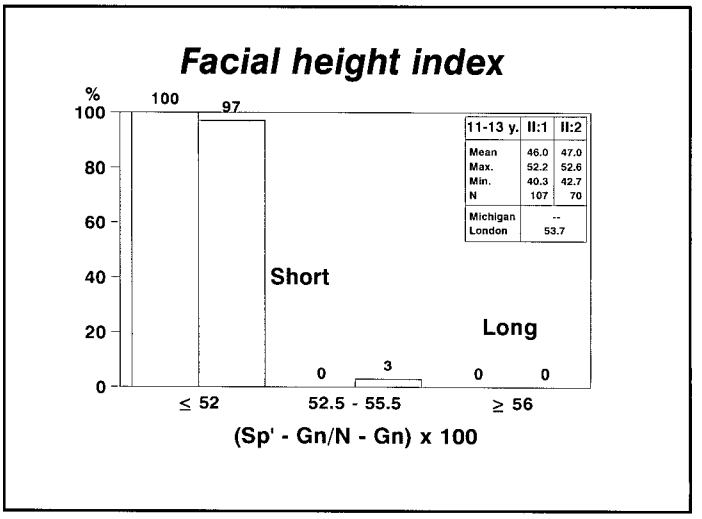

Figure 9B

an age difference found for L1/ML (Table 3) or for the frequency of subjects exhibiting incisor proclination or retroclination (Figure 11).

Discussion

This study of the dentoskeletal morphology of Class II division 1 and division 2 malocclusions was based on a large number of Caucasian children at the ages of 8-10 years and 11-13 years. In the majority of the children, the two age ranges corresponded to the early and late mixed dentition periods, respectively. In the orthopedic treatment of Class II malocclusions, age may have a decisive bearing on the choice of therapeutic approach, e.g., functional or fixed appliances, nonextraction or extraction therapy.

In order not to be influenced by skeletofacial morphology, subject selection was based exclusively on dental cast analyses. Strict criteria for inclusion were used. For cases in the mixed dentition a bilateral distal molar relationship of more than one-half cusp width had to be present. This applied to both Class II division 1 and Class II division 2 cases. An end-on molar relationship in the presence of deciduous second molars was not considered to be a Class II[18] but rather a Class I malocclusion.[34] However, for cases in which the permanent teeth in the lateral segments had erupted, a bilateral distal molar and canine relationship of one-half cusp width was considered sufficient for assigning the case as a Class II malocclusion.[34]

The overbite was of no importance in the selection of Class II division 1 malocclusions. Thus, both open bite and deep bite cases (with a large overjet) were included. In the selection of Class II division 2 malocclusions, on the other hand, only deep bite cases (with retroclined upper front teeth) were considered.

The findings of this study revealed that neither Class II division 1 nor division 2 malocclusions were single clinical entities and, with the exception of maxillary incisor position, no basic mor-

Figure 8A-B
Distribution of the NL/ML angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Figure 9A-B
Distribution of the Facial height index: (Sp´-GN/N - Gn) x 100 in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

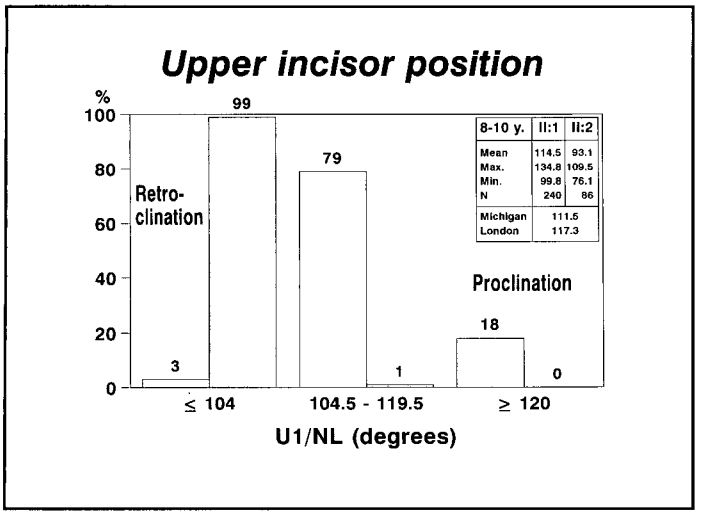

Figure 10A

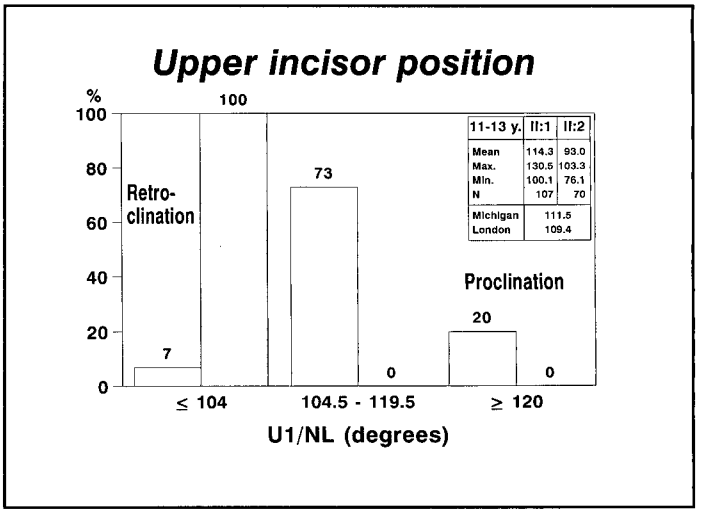

Figure 10B

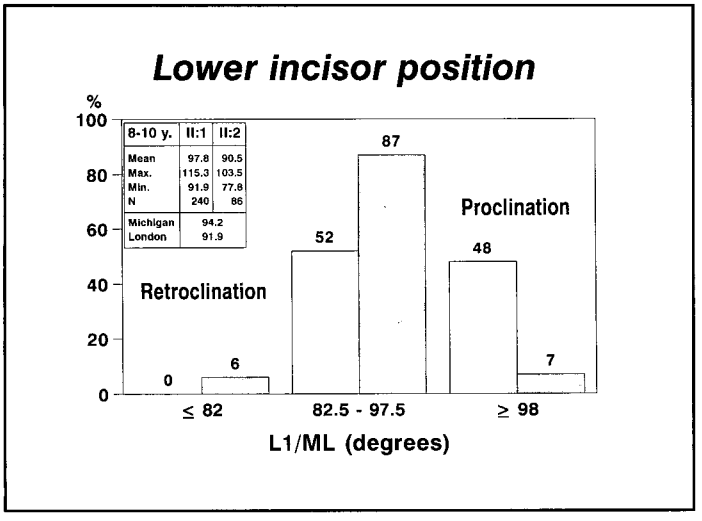

Figure 11A

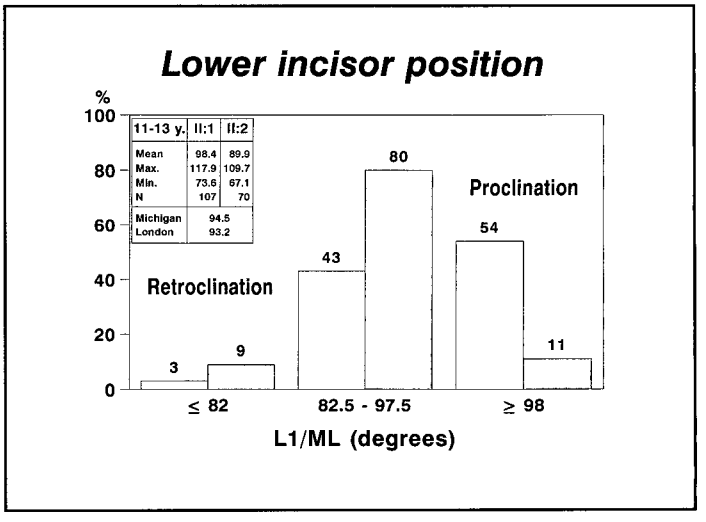

Figure 11B

Figure 10A-B
Distribution of the U1/NL angle in the Class II division 1 and Class II division 2 samples.
A: Age 8-10 years.
B: Age 11-13 years.

Figure 11A-B
Distribution of the L1/ML angle in the Class II division 1 and Class II division 2 samples
A: Age 8-10 years.
B: Age 11-13 years.

phologic differences existed between the two malocclusions. Irrespective of the age of the subjects, a broad variation in dentoskeletal morphology prevailed in the two Class II malocclusion samples.

In both samples the frequency of cases exhibiting maxillary retrusion (viz., a small SNA angle) was relatively high. This is in agreement with Harris et al.[15] but in disagreement with Korkhaus,[23] Blair,[9] Rothstein,[14] and Rosenblum[22] who found maxillary protrusion to be a dominant component of Class II malocclusion. Differences in the methods of registering maxillary position may explain the various findings.

Considering mandibular position (SNB, SNPg), mandibular retrusion was a common characteristic of both division 1 and division 2 samples.[5-7,9,11,12,15,16,18,21,23,35,36] Due to normal mandibular growth and development[32,33] the frequency of mandibular retrusion was expected to be lower in the older than in the younger subjects. This was also the case for the Class II division 1 sample, but not for the division 2. Possibly due to the retroclined maxillary incisors combined with the deep bite, mandibular growth was restricted in the Class II division 2 subjects. This assumption is confirmed by the observation that in these cases dentoalveolar development (SNB) was restrained more than basal development (SNPg).[23,35,37]

It could possibly be argued that in the horizontal analysis, sella-nasion-based angular indicators could lead to erroneous results.[22] However, when analyzing the present Class II division 1[38] and Class II division 2[39] material using Frankfort horizontal-based indicators (Facial angle, A-N Perpendiculare, PG-N Perpendiculare), similar results with respect to maxillary and mandibular positions were found as when using S-N as a baseline.[38,39] Furthermore, it is standard practice to use the angles SNA, SNB, and SNPg for craniofacial morphologic assessments. Conformity in

the usage of variables will, of course, facilitate the communication between clinicians as well as between research workers.

Mainly as a result of the high frequency of subjects with mandibular retrusion, the two angles describing sagittal jaw base relationships (ANB, ANPg) were, on average, larger in the two malocclusion samples. Thus, a skeletal Class II jaw relationship was found in a large percentage of subjects (46% - 76%).

For the Class II division 1 malocclusions, the reduction in the number of skeletal Class II cases with age may, as mentioned earlier, be due to the possibility that mandibular growth was unrestricted anteriorly. In the Class II division 2 malocclusions, on the other hand, the retroclined maxillary incisors might hinder sagittal mandibular growth development.

When considering the vertical jaw base relationship, the angles ML/NSL and NL/ML in the two malocclusion samples were, on average, smaller in comparison with the Michigan[32] and London[33] reference data. This is in agreement with the findings of other studies of Class II division 2 malocclusions.[29,37] It must be pointed out, however, that the variation of the ML/NSL and NL/ML in both malocclusion samples was great. Both low angle (hypodivergent) and high angle (hyperdivergent) cases existed. For the Class II division 1 sample, the findings corresponded to those of McNamara.[18]

The average reduction of the ML/NSL angle (Class II division 1) and increase in the number of low angle cases (division 1 and division 2) with age may be due to an anterior mandibular growth rotation,[21,27,40] which is thought to occur especially in cases with deficient incisal support.[27,41] However, the possibility cannot be excluded that part of the rotational effects of mandibular growth are masked by compensatory remodeling processes at the lower jaw border.[40,42]

In the present investigation, short lower face height was a consistent finding in both malocclusion samples (97% - 100%). Similar results were found in other Class II division 2[23,25,27,31,35] and Class II division 1[21,36] studies. In contrast, excessive vertical development of the lower face was found in the Class II division 1 studies of Henry,[11] Hunter,[12] and McNamara.[18]

The mandibular incisors (L1/ML) behaved differently in the two malocclusion samples. Compared with the reference data, they were more proclined in the Class II division 1 group and more retroclined in the Class II division 2 group. This was thought to result mainly from dentoalveolar compensation[43] in response to mandibular retrusion (Class II division 1) and upper incisor retroclination (Class II division 2). However, marked lower incisor retroclination in the Class II division 2 malocclusions was found in only 6% - 9% of the subjects. In the Class II division 1 malocclusions, on the other hand, marked lower incisor proclination was present in approximately 50% of the cases. In other studies, relatively normal inclination [15,16] and position [18] of the mandibular incisors was found in Class II division 1 malocclusions.

Conclusions

This cephalometric radiographic study of 347 Class II division 1 and 156 Class II division 2 malocclusions divided into age groups 8-10 years and 11-13 years revealed no basic differences in dentoskeletal morphology (with the exception of maxillary incisor position) between the two malocclusion samples. Broad variations in variables existed. In both malocclusion samples as well as age groups mandibular retrusion was a common finding, while short lower face height was a consistent finding.

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