Original Article

Dental Arch Widths and Mandibular-Maxillary Base Widths in Class II Malocclusions Between Early Mixed and Permanent Dentitions

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Abstract: The aim of the study was to analyze the transverse morphology and development of the dental arches and skeletal mandibular-maxillary bases in untreated Class II malocclusions. Using the records of the Belfast Growth Study, a Class II division 1 group (II/1) and a Class II division 2 group (II/2) were compared with a Class I group and a control group with good occlusion. On posteroanterior cephalograms, maxillary skeletal base width and bigonial and biantegonial widths were determined at two-year intervals between seven and 15 years. Maxillary and mandibular intermolar widths were measured on the associated study casts. As a result, maxillary skeletal base widths were smallest in the Class II/1 subjects. No statistically significant differences were found among the groups for the skeletal mandibular widths. With respect to the development of the dental arches, maxillary intermolar widths were smaller in the Class II/1 group than in the Class I and the good-occlusion groups. These group differences were present for the total period of observation, ie, seven to 15 years, and statistically significant at most ages. When the relative difference between the maxillary and the mandibular intermolar widths was examined, the Class II/1 cases were found to have the largest average difference (about −2.5 mm for boys and −1.5 mm for girls), indicating a relatively narrow maxillary arch. Less pronounced molar differences were found in the Class II/2 group. In the Class II/1 subjects the deviations in molar differences observed at 15 years of age were established already at 7 years of age and maintained during 7 and 15 years of age. (*Angle Orthod* 2003; 73:674–685.)

Key Words: Transverse development; Class II division 1; Class II division 2; PA cephalometry; Model analysis

INTRODUCTION

Modern orthodontics offers a multitude of treatment options for the correction of transverse discrepancies of the dental arches.[1] In the treatment planning of buccolingual anomalies, besides functional aspects such as oral respiration, transverse morphology and growth potential in Class II malocclusions have to be taken into account. A number of studies predominantly based on Class I samples or samples with a range of malocclusions have addressed the transverse development of skeletal mandibular-maxillary bases[2–9] as well as the width changes of dental arches.[10–18]

In contrast, few studies have focused on the transverse morphology and growth in Class II malocclusions. Fröhlich[19] studied dental casts of untreated individuals with Class II division 1 (II/1) and Class II division 2 malocclusions from deciduous to permanent dentition. He found that the absolute dental arch breadths in Class II cases did not differ appreciably from the normative data published by Moorrees.[20]

In adult samples, Staley et al[21] and Buschang et al[22] compared arch widths in normal-occlusion or Class I groups with Class II malocclusions. In the study by Staley et al[21], the maxillary dental arch was narrower in the Class II division 1 malocclusion, and Buschang et al[22] found the longest and narrowest maxillary arches with respect to arch shape in girls with Class II/1 malocclusion. In addi-

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TABLE 1. Age Structure (Means and Standard Deviations in Years) of the Subjects During the Radiographs

		t1		t2		t3		t4		t5	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Good occlusion	Boys	7.52	0.33	9.36	0.37	11.44	0.34	13.50	0.35	15.55	0.36
	Girls	7.71	0.31	9.67	0.32	11.71	0.30	13.71	0.33	15.78	0.36
Class I	Boys	7.64	0.35	9.45	0.33	11.50	0.33	13.55	0.32	15.61	0.32
	Girls	7.60	0.25	9.57	0.25	11.61	0.24	13.60	0.29	15.66	0.31
Class II/1	Boys	7.49	0.36	9.35	0.38	11.46	0.32	13.54	0.36	15.60	0.47
	Girls	7.52	0.30	9.56	0.30	11.54	0.32	13.60	0.34	15.59	0.35
Class II/2	Boys	7.82	0.39	9.69	0.36	11.58	0.22	13.57	0.27	15.59	0.25
	Girls	7.53	0.34	9.53	0.35	11.54	0.45	13.52	0.34	15.68	0.51

tion, Staley et al[21] analyzed the differences in first molar widths between the upper and lower jaws, and the clinical usefulness of this width difference was pointed out with respect to determining the severity of molar crossbite problems.

Using models and lateral cephalograms, Tollaro et al[23] investigated the relationship between posterior transverse interarch discrepancy and mandibular size and position. Like Staley et al,[21] they calculated the posterior transverse interarch discrepancy as the difference between maxillary and mandibular intermolar widths. This interarch discrepancy turned out to be a simple and effective parameter for assessing the transverse congruence of dental arches.

Bishara et al[24] compared the dental casts of normal subjects with untreated Class II division 1 subjects from the Iowa Growth Study. The dental arches were analyzed longitudinally at five, eight, and 13 years, and arch width was measured at the second deciduous molars and the succedaneous premolars. They found a relative constriction of the maxillary intermolar width in the Class II division 1 group, which was statistically significant only in boys. Baccetti et al[25] investigated the early dentofacial features of Class II malocclusion. They found that during the transition from the deciduous to the mixed dentition the occlusal Class II features were maintained or exaggerated. Alarashi et al[26] investigated the transverse dentoskeletal features of Class II malocclusion around eight years of age by means of thin-plate spline analysis. They found a contraction of the maxilla at both the skeletal and dentoalveolar levels in Class II malocclusion cases.

Staley et al[21] reported that there is a paucity of information about the differences in transverse dental arch dimensions between Class I and Class II cases. Moreover, information is still scarce with respect to the differential development of skeletal mandibular-maxillary widths in the various types of malocclusion, ie, Class I vs Class II malocclusions. Finally, as has been pointed out by Bishara et al,[24] there is still a certain degree of controversy about the transverse dental arch parameters in Class II division 1 malocclusion.

Hence, the aim of the present study was to analyze using longitudinal data the morphology and development of dental arches in Class division 1 and Class II division 2 cases in a clinically relevant period of development, ie, seven to 15 years of age. In addition, the transverse development of the skeletal mandibular-maxillary bases was depicted as well to gain insight into underlying skeletal growth patterns.

MATERIALS AND METHODS

This longitudinal study examined the posteroanterior (PA) cephalograms and dental casts of orthodontically untreated subjects from the Belfast Growth Study.[27] The Belfast Growth Study was carried out by C. P. Adams with 300 children, for whom PA and lateral cephalograms were taken annually and plaster casts made every six months. Each child was examined in 21 visits beginning at the age of 5 years (first visit) up to the age of 15 years (21st visit). In the present investigation, subjects were selected that met, based on the models at age 15 years, the following inclusion criteria:

- Class I group (n = 37; 19 boys, 18 girls): (1) bilateral Class I molar and canine relationship and (2) full permanent dentition except third molars
- Good-occlusion group (n = 18; 10 boys, eight girls): (1 and 2) inclusion criteria of the Class I group, (3) correct overjet and overbite (≥1 and ≤4 mm), (4) no crossbites or transverse anomalies, and (5) crowding in the upper and lower jaws ≤3 mm.

Inclusion criteria for the Class II groups: (1) full permanent dentition and (2) Class II molar and canine relationship ≥½ of a premolar width, at least on one side. Additional inclusion criteria for subsequent allocation to the Class II division 1 and Class II division 2 groups were

- Class II division 1 group (II/1) (n = 17; eight boys, nine girls): proclination of upper front teeth with overjet ≥5 mm
- Class II division 2 group (II/2) (n = 12; eight boys, four girls): retroclination of upper incisors, at least of the two central incisors.

In the Class II/2 group, one subject was included, in whom an upper canine had not yet erupted by age 15 years (persisting deciduous canine). In the Class II/1 group, one

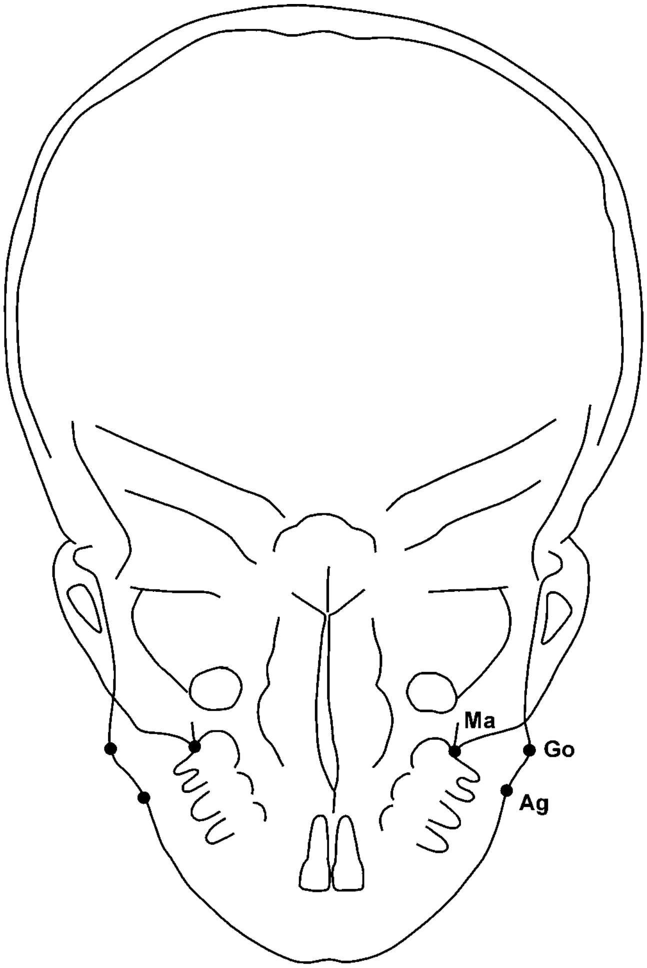

FIGURE 1. Tracing of PA radiograph in depressed view showing the skeletal mandibular-maxillary landmarks used. Ma indicates maxillare-maxillary skeletal base width; Go, gonion-bigonial width; Ag, antegonion-biantegonial width.

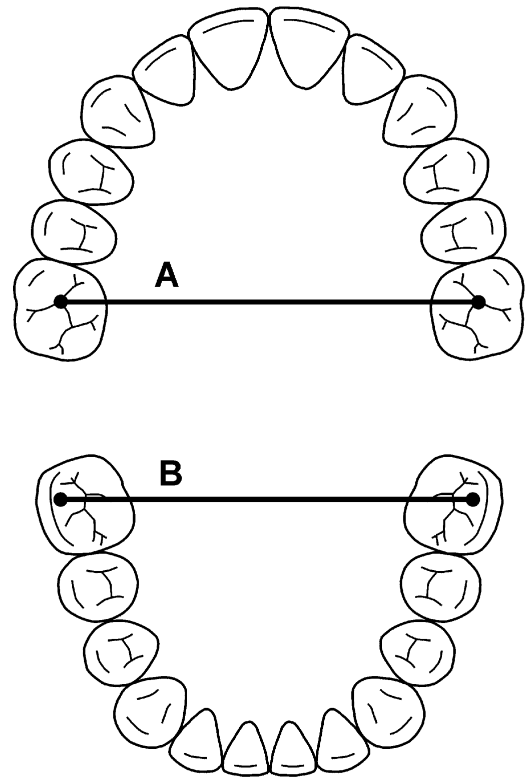

FIGURE 2. Measurements on the models. (A) Maxillary intermolar width: distance between the central fossae of the right and left first maxillary molars. (B) Mandibular intermolar width: distance between the tips of the distobuccal cusps of the right and left first mandibular molars. In addition, molar difference (=A minus B) was determined.

girl showed a greatly delayed eruption of a lower first molar and was excluded from the model analysis.

Age structure

Changes in width dimensions were analyzed on the basis of PA cephalograms and models at two-yearly intervals (seven, nine, 11, 13, and 15 years). The age when the radiographs were taken is given in Table 1. The study models were taken at the same time points as the radiographs. Nevertheless, in particular at age 7 years, slight differences emerged because in a few subjects the molars had not fully erupted by the age of seven years, and models taken mainly six months later were used to determine intermolar widths.

Measurements—PA radiographs

In the Belfast Growth Study, the PA radiographs were taken in the depressed PA view.[28] In this view, the Frankfurt Horizontal is inclined downward at an angle of 35° to the horizontal plane. This projection permits an overview of the whole mandible, which favors a determination of bigonial and biantegonial widths. The PA and lateral cephalograms were scanned with high resolution (600 dpi). After digitizing the PA landmarks, the landmark coordinates were used to calculate the following three skeletal widths (Figure 1).

Maxillary skeletal base width. This is the distance between right and left maxillares (Ma). Maxillare is the intersection of the lateral contour of the maxillary alveolar process and the lower contour of the maxillozygomatic process of the maxilla.[6,29,30]

Bigonial width. This is the distance between both Gonia (Go). Gonion is the most inferior, posterior, and lateral point on the external angle of the mandible.[31]

Biantegonial width. This is the distance between both antegonia (Ag). Antegonion is the deepest point on the curvature at the antegonial notch.[6,32,33]

All radiographic measurements were corrected for magnification. The differential magnification in the PA cephalograms was corrected using the method of similar triangles.[28,30] Because this method is based on a three-dimensional identification of landmarks, lateral cephalograms taken at the same times were analyzed as well.

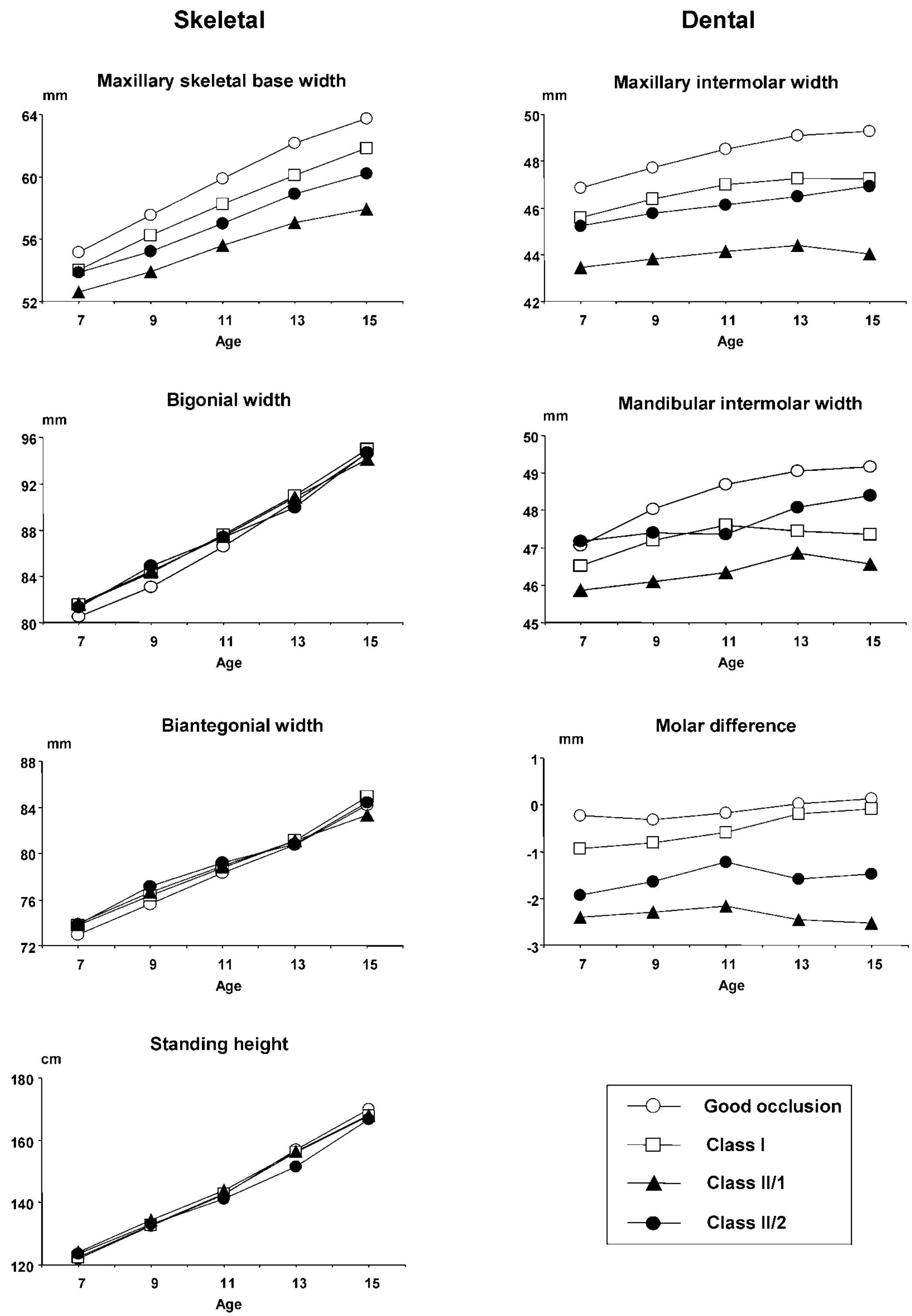

FIGURE 3. Boys: growth curves showing size vs time for the three skeletal (left column) and the three dental variables (right column) in two-year intervals between seven and 15 years of age, separately for each group. In addition, standing height is depicted at the bottom.

Measurements—dental widths

Measurements of the transverse development of the dental arches were made on the models with a dial caliper (Mitutoyo Absolute Digimatic Caliper, Tokyo, Japan) to the nearest 0.02 mm. The following dental widths[23,34] were determined (Figure 2):

- Maxillary intermolar width: distance between the central fossae of the right and left first maxillary molars;

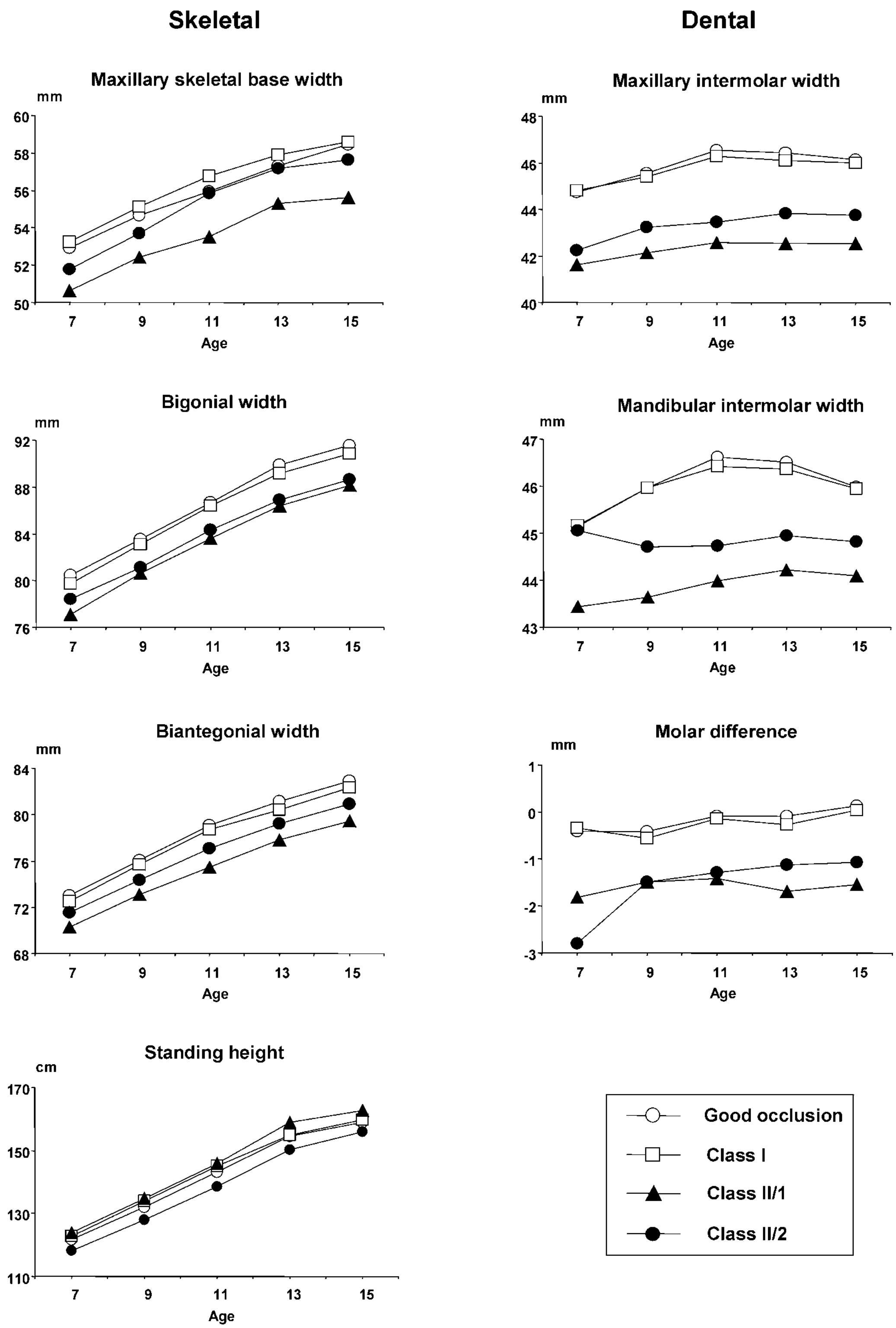

FIGURE 4. Girls: growth curves showing size vs time for the three skeletal (left column) and the three dental variables (right column) in two-year intervals between seven and 15 years of age, separately for each group. In addition, standing height is depicted at the bottom.

- Mandibular intermolar width: distance between the tips of the distobuccal cusps of the right and left first mandibular molars;
- Molar difference: difference between the maxillary and mandibular intermolar widths. In Class I subjects with normal occlusion, these measurement points are on top of each other; hence, maxillary and mandibular intermolar widths are equal, and the molar difference is zero in subjects with normal occlusion.[23]

Measurement error

Replicate measurements on 20 PA cephalograms, 20 lateral cephalograms, and 20 models were used for evaluating the measurement error according to Dahlberg's[35] formula. The error of the method for the measurements on the dental casts was 0.17 mm for maxillary intermolar width, 0.25 mm for mandibular intermolar width, and 0.31 mm for molar difference. Measurement errors made on the radiographs were 0.50 mm for biantegonial width, 0.56 mm for maxillary skeletal base width, and 0.61 mm for bigonial width.

Data analysis and statistical methods

Growth curves showing absolute size vs time were calculated to depict the growth behavior of the various craniofacial widths in the four groups, separately for boys and girls. In addition, descriptive statistics for the dental and skeletal widths at seven, nine, 11, 13, and 15 years including mean, standard deviation, and range are given. A Wilcoxon rank sum test was used for the pairwise testing of group differences among the four groups. No statistical testing was carried out between the Class I and the good-occlusion groups. A conservative significance level of $P \leq .01$ was chosen, which satisfies a Bonferroni correction for the multiple testing ($n = 5$) of intergroup differences. Nonparametric tests were used, also with respect to the small sample sizes.

RESULTS

Figures 3 and 4 show the growth curves in the four groups, separately for boys (Figure 3) and girls (Figure 4). Descriptive statistics of the skeletal and dental variables are given in Table 2 for the boys and in Table 3 for the girls. *P* values of the group differences are shown in Table 4.

Group differences—boys

In the skeletal widths (Figure 3; Table 2), the four groups differ in maxillary skeletal base width among the boys. The good-occlusion group shows the most pronounced development of the maxillary skeletal base, followed by the Class I and the Class II/2 cases. The smallest maxillary base width is present in the Class II/1 group. The differences between the Class II/1 and the good-occlusion groups are statistically significant at all ages, the differences between the Class II/1 and the Class I groups are so at age 15 years (Table 4). In contrast, no group differences can be found for skeletal mandibular widths, namely, bigonial and biantegonial widths, where the growth curves of the four groups are almost congruent (Figure 3).

Regarding the transverse development of the dental arches (Figure 3), a group configuration similar to maxillary skeletal base width becomes apparent in maxillary intermolar width. Again, the good-occlusion cases show the largest maxillary intermolar widths and the Class II/1 subjects the smallest ones. In maxillary intermolar widths, group differences between the good-occlusion group and the II/1 subjects are significant at all ages, and between the good-occlusion and the Class II/1 groups they are so at 11 and 13 years. Moreover, at age 15 years, group differences between the Class II/1 and the Class II/2 subjects are statistically significant (Table 4). The growth curves of mandibular intermolar widths also indicate group differences, which are, however, statistically not significant at any age. Finally, pronounced group differences were found for molar differences (Figure 3; Table 4). In both the good-occlusion and the Class I groups, this variable approximates zero at age 15 years, which indicates no transverse discrepancy between the upper and lower arches in the permanent dentition. At age 15 years, the Class II/2 cases show a molar difference of around −1.5 mm. Molar differences are most pronounced in the Class II/1 cases, on an average approximately −2.5 mm, ie, the upper intermolar width is relatively narrow as indicated by the negative sign. In the Class II/1 group, the molar differences did not improve during development (Figure 3). At 13 and 15 years, the differences between the Class I and the Class II/1 groups were statistically significant. Hence, in the Class II/1 subjects the deviations in molar differences oberved at 15 years of age were established already at 7 years of age (or before) and maintained during 7 and 15 years of age. The standing height measurements are also illustrated in Figure 3, and they reveal a comparable development of total body height in the four groups.

Group differences—girls

With respect to skeletal development, the mean maxillary skeletal base widths (Figure 4; Table 3) were also smallest in the female Class II/1 group. As with the boys, no significant group differences were found in bigonial and biantegonial widths.

Regarding dental arch widths, Class II/1 subjects again showed the smallest maxillary intermolar widths during the total period of observation. In Figure 4, the growth curves for the female Class II/2 group are also depicted, but their relevance is limited on account of the small sample size of that group. As with the boys, the Class II/2 cases take up a position between the Class II/1 cases on the one hand and the Class I and good-occlusion cases on the other. In the

TABLE 2. Boys' Descriptive Statistics for the Three Skeletal and the Three Dental Variables in the Four Groups, Including Mean, Standard Deviation and Range

		Good Occlusion				Class I			
Variable	Age	Mean	SD	Min	Max	Mean	SD	Min	Max
Skeletal widths									
Maxillary skeletal base width	7	55.14	1.63	52.12	57.99	54.00	3.00	47.43	57.99
	9	57.55	1.93	53.47	60.65	56.24	3.04	50.72	60.65
	11	59.89	2.05	56.17	63.00	58.27	3.10	52.57	63.00
	13	62.17	2.33	59.05	65.93	60.12	3.55	53.90	65.93
	15	63.75	2.46	59.46	68.17	61.81	3.08	56.30	68.17
Bigonial width	7	80.50	3.01	75.47	84.81	81.53	3.89	75.37	87.25
	9	83.05	3.51	77.96	88.80	84.28	4.30	77.91	90.79
	11	86.54	3.93	80.70	92.79	87.61	4.43	80.70	94.43
	13	90.44	3.93	83.10	96.45	90.98	4.60	82.70	97.82
	15	94.64	4.63	87.46	101.2	94.96	5.22	84.80	101.6
Biantegional width	7	72.94	2.41	69.25	76.92	73.73	3.30	68.59	80.17
	9	75.59	3.23	71.62	81.64	76.35	3.80	71.39	83.64
	11	78.29	2.76	75.29	83.23	78.74	3.48	73.16	85.65
	13	80.71	3.39	77.79	88.21	81.12	4.00	74.57	88.21
	15	84.16	3.51	78.97	90.87	84.93	4.40	77.23	92.98
Dental widths									
Maxillary intermolar width	7	46.84	2.08	42.81	50.13	45.57	2.47	41.18	50.13
	9	47.71	1.96	44.09	50.97	46.39	2.43	41.98	50.97
	11	48.51	2.52	44.78	52.44	47.01	2.65	42.81	52.44
	13	49.08	2.69	44.30	53.41	47.24	2.95	42.68	53.41
	15	49.28	2.61	44.72	52.96	47.27	3.11	42.56	52.96
Mandibular intermolar width	7	47.07	2.09	44.41	50.59	46.51	1.85	43.59	50.59
	9	48.02	2.03	45.02	51.37	47.21	2.04	43.47	51.37
	11	48.68	2.36	44.97	52.58	47.59	2.37	43.62	52.58
	13	49.05	2.56	44.68	53.70	47.44	2.83	43.35	53.70
	15	49.16	2.51	44.93	52.61	47.36	3.18	42.38	52.61
Molar difference	7	−0.22	0.67	−1.60	0.42	−0.93	1.83	−7.45	0.42
	9	−0.32	0.48	−1.18	0.22	−0.81	1.49	−6.58	0.22
	11	−0.17	0.45	−1.21	0.44	−0.59	1.25	−5.40	0.44
	13	0.03	0.51	−0.39	1.28	−0.20	1.06	−4.03	1.30
	15	0.13	0.68	−0.73	1.78	−0.09	1.10	−3.66	1.78

comparison between the Class I and Class II/1 groups, the differences in maxillary intermolar widths were statistically significant at almost all ages (Table 4). Also in mandibular intermolar widths, the Class II/1 cases show the smallest values, but the differences were not statistically significant. As with the boys, the molar difference in the Class I and the good-occlusion groups approximates zero at age 15 years, ie, there were no interarch discrepancies. The female Class II/1 group displays the most pronounced molar differences. As with the boys, in the Class II/1 subjects, the molar differences were maintained during development, and at age 13 and 15 years, the group differences between Class I and Class II/1 subjects were statistically significant. Finally, in all groups and in both sexes, intermolar widths show only small relative increments (Figures 3 and 4) in contrast to the skeletal widths with a greater remaining growth potential. This restricted development of the dental arches is most pronounced in the girls after 11 years (Figure 4).

DISCUSSION

In the present study, the transverse development in Class II malocclusion was compared with two control groups, a good-occlusion group and a Class I group, with all kinds of anomalies, such as severe crowding. Similar control groups have been used independently in previous studies comparing Class I with Class II groups. Some authors[21,24,36,37] used Class I control groups with well-aligned arches, ie, only little crowding or no major malpositions of teeth. Other studies[22,23,38–40] used, for analyzing Class II malocclusions, Class I groups without an exclusion of malpositions or malocclusions of teeth. The growth curves for the Class I groups show slightly smaller values in many transverse dimensions than those recorded for the good-occlusion groups (Figure 3). This observation may at least partly be explained by additional factors such as severe crowding and may underscore the usefulness of differentiating between a Class I group and a good-occlusion group in the analysis of transverse growth.

TABLE 2. Extended

Class II/1				Class II/2			
Mean	SD	Min	Max	Mean	SD	Min	Max
52.59	0.91	51.48	54.42	53.83	2.37	50.77	57.72
53.87	1.09	51.88	55.07	55.22	2.41	51.31	58.25
55.59	1.24	54.13	57.21	57.01	2.97	52.12	61.27
57.07	0.78	56.32	58.76	58.92	2.54	55.12	63.25
57.90	0.59	57.05	58.93	60.21	2.79	56.32	65.44
81.58	3.35	75.79	86.95	81.34	4.81	74.68	88.28
84.45	2.94	79.11	87.94	84.86	4.20	77.83	89.79
87.43	3.44	82.09	93.37	87.35	4.25	80.64	92.23
90.81	3.91	85.17	95.35	89.92	3.89	84.66	94.06
94.12	3.78	89.65	100.17	94.65	3.73	89.09	98.05
73.90	2.97	71.34	78.76	73.83	3.05	69.17	78.49
76.65	2.22	73.91	80.23	77.12	2.35	72.92	80.00
78.88	3.00	76.02	83.29	79.19	2.93	75.15	82.61
81.11	3.93	76.59	88.02	80.83	2.88	77.26	84.97
83.28	2.99	79.98	88.13	84.41	3.07	80.35	89.62
43.45	1.30	41.46	45.65	45.24	2.30	42.05	48.18
43.80	1.00	42.36	45.66	45.76	2.65	42.44	50.38
44.15	1.00	42.86	46.01	46.12	2.67	42.37	50.35
44.39	1.06	42.48	45.53	46.48	2.20	42.90	50.25
44.03	1.53	41.92	45.96	46.91	1.98	43.59	50.28
45.86	2.39	43.10	50.27	47.18	2.31	42.98	50.67
46.09	2.58	43.09	51.18	47.40	2.45	43.11	51.43
46.32	2.56	42.96	51.22	47.34	2.52	43.72	51.95
46.85	2.90	42.62	52.26	48.08	2.15	45.27	52.07
46.57	3.03	43.02	52.64	48.40	1.77	46.71	52.20
−2.41	2.28	−6.42	−0.40	−1.94	1.60	−5.26	−0.03
−2.29	2.22	−7.02	−0.03	−1.64	1.57	−5.04	0.11
−2.17	2.21	−6.33	−0.10	−1.22	2.06	−5.91	0.34
−2.46	2.22	−6.83	−0.14	−1.60	1.98	−6.30	0.23
−2.53	2.05	−6.68	−0.26	−1.49	1.86	−5.82	0.20

In the present study, significant differences concerning skeletal and dental widths were found among the four groups. The additional depiction of standing height (Figures 3 and 4) indicates that these differences in dental and skeletal mandibular-maxillary widths cannot simply be explained by differences in the absolute sizes of the subjects.

In the study by Bishara et al[24], the differences between maxillary and mandibular intermolar widths were significantly larger in boys with normal occlusion when compared with Class II/1 subjects. In girls, they found the same tendency, but group differences were not statistically significant. Moreover, in their study a relative constriction of the upper arch was present at all developmental stages, ie, deciduous, mixed, and permanent dentitions. This is in keeping with the results of the present study, where in both sexes, a molar difference was found due to a smaller transverse maxillary skeletal base and a narrower maxillary intermolar distance. Molar differences in the Class II/1 groups were greater in boys than in girls. Moreover, the fact that in the Class II/1 groups the deviations in molar differences were maintained between 7 and 15 years is similar to the results of Baccetti et al,[25] who investigated the transition from deciduous to early mixed dentition. In the comparison between Class I and Class II/1 groups, significant group differences with respect to molar difference were found at 13 and 15 years, both in boys and girls. In this context, Staley et al[21] and Bishara et al[24] pointed out that it is clinically useful to compare differences between molar widths besides comparing absolute molar widths because on the basis of such differences more consistent and interpretable results could be obtained.[24]

In adult subjects with normal occlusion, Staley et al[21] found significantly larger maxillary intermolar widths than in subjects with Class II/1 malocclusion. In contrast, Fröhlich[19] concluded that the absolute dental arch breadths of Class II children did not differ appreciably from normative data. Moreover, in Fröhlich's[19] study, the increments in the maxillary and mandibular arch breadths between six and 12 years conformed to the normative pattern. In the present study, at age 15 years—ie, slightly younger than the adult

TABLE 3. Girls' Descriptive Statistics for the Three Skeletal and the Three Dental Variables in the Four Groups, Including Mean, Standard Deviation and Range

		Good Occlusion				Class I			
Variable	Age	Mean	SD	Min	Max	Mean	SD	Min	Max
Skeletal widths									
Maxillary skeletal base width	7	52.93	2.10	49.25	55.84	53.25	3.00	46.32	57.80
	9	54.67	1.88	51.57	57.01	55.10	3.06	48.83	61.95
	11	55.91	2.40	51.40	59.04	56.75	3.87	47.79	64.67
	13	57.30	2.40	53.47	60.95	57.90	3.75	49.71	64.52
	15	58.46	2.84	52.25	62.07	58.60	3.63	51.09	65.13
Bigonial width	7	80.48	3.81	76.27	85.88	79.74	5.38	72.04	91.75
	9	83.52	3.12	79.11	87.35	83.09	5.14	75.28	95.26
	11	86.68	3.17	83.06	90.94	86.40	5.64	76.98	99.85
	13	89.86	3.22	85.88	94.39	89.17	6.13	78.80	103.03
	15	91.54	3.17	88.28	96.58	90.84	5.88	80.32	102.53
Biantegonial width	7	73.02	3.70	68.55	77.74	72.49	4.58	65.65	82.01
	9	76.01	3.46	70.98	80.13	75.70	4.67	68.64	85.72
	11	79.07	3.42	74.10	83.54	78.66	5.00	69.39	89.29
	13	81.13	4.16	75.20	87.12	80.36	5.76	70.30	93.38
	15	82.92	3.57	77.14	88.06	82.28	5.63	72.74	95.75
Dental widths									
Maxillary intermolar width	7	44.73	1.52	42.12	46.66	44.80	2.36	39.00	48.55
	9	45.56	1.80	42.63	47.57	45.40	2.52	39.40	48.92
	11	46.53	1.96	42.70	48.68	46.28	2.51	40.26	49.96
	13	46.41	1.97	43.17	48.62	46.10	2.42	40.89	49.98
	15	46.11	1.62	43.30	47.90	45.99	2.12	42.17	49.38
Mandibular intermolar width	7	45.15	2.35	41.14	47.69	45.16	2.72	38.75	48.81
	9	45.97	2.11	42.46	48.20	45.96	2.72	39.40	49.78
	11	46.61	2.19	42.70	48.83	46.42	2.60	39.96	50.32
	13	46.51	2.11	43.23	48.80	46.37	2.58	40.61	50.96
	15	45.99	1.74	43.29	48.50	45.94	2.40	41.65	50.88
Molar difference	7	−0.42	1.04	−2.16	0.98	−0.35	0.90	−2.16	1.22
	9	−0.41	0.50	−1.08	0.17	−0.56	0.76	−2.17	0.41
	11	−0.09	0.45	−0.77	0.67	−0.14	0.86	−2.78	1.00
	13	−0.09	0.78	−1.84	0.81	0.28	0.71	−1.84	0.81
	15	0.13	0.80	−1.43	1.14	0.04	0.73	−1.50	1.14

patients used in the study of Staley et al[21]—maxillary intermolar widths were about 3–5 mm smaller in the Class II/1 groups than in the Class I and good-occlusion groups, which supports the results of Staley et al[21]. With respect to mandibular intermolar width, Staley et al[21] found that only male subjects with normal occlusion had significantly larger mandibular intermolar widths when compared with the Class II group. Although in the present study group differences between the Class II/1 and the good-occlusion groups were not statistically significant, they were greater in boys than in girls, which supports the observation of Staley's[21]. With respect to molar differences, Staley et al,[21] using different molar measurement points than those used in the present study, found that among boys the normal-occlusion and the Class II/1 groups differed by 4.5 mm (molar differences: 1.6 vs −2.9 mm) and among the girls by 3.6 mm (1.2 vs −2.4 mm). In the present study, at age 15 years, molar differences in the Class II/1 groups were about −2.5 mm (boys) and −1.5 mm (girls) in contrast to approximately 0 mm in the good-occlusion and the Class I groups. Hence, group differences between the Class I and the II/1 groups were less pronounced than in the study of Staley et al[21]; nevertheless, they were statistically significant in both sexes at age 13 and 15 years with respect to interarch discrepancies. Buschang et al[22] reported that in an adult female sample, Class II cases were smaller than Class I subjects with respect to maxillary intermolar width. Within the Class II malocclusion group, maxillary width was smaller in the Class II/1 group than in the Class II/2 subjects. Although a comparison is difficult because of the different age structure, similar results were obtained in the present study where the Class II/2 cases took up a position between the Class II/1 cases and the Class I control groups.

Tollaro et al[23] divided Class II malocclusions into subjects with and without posterior transverse interarch discrepancy (=molar difference). They found that in Class II cases where there was an interarch discrepancy, this was due to a significantly narrower maxillary arch. In those subjects, no significant differences were found in mandibular intermolar widths. This is in keeping with the present study,

TABLE 3. Extended

Class II/1				Class II/2			
Mean	SD	Min	Max	Mean	SD	Min	Max
50.64	2.01	47.53	53.75	51.79	1.52	50.76	54.03
52.40	1.86	49.84	55.33	53.71	1.55	52.69	56.01
53.50	2.07	50.45	57.15	55.85	1.58	53.78	57.28
55.31	2.34	52.74	59.38	57.16	1.52	55.10	58.43
55.60	2.24	53.08	59.37	57.61	1.26	56.17	59.06
77.10	4.36	71.69	83.07	78.44	4.33	73.99	84.17
80.60	4.13	75.44	85.62	81.08	4.54	76.00	86.78
83.58	3.96	78.71	88.90	84.33	4.53	79.54	90.43
86.34	3.59	81.60	91.94	86.88	5.12	81.41	93.70
88.11	3.44	83.59	92.75	88.65	5.33	82.96	95.71
70.26	3.38	66.68	75.51	71.55	2.71	68.39	74.54
73.07	3.07	69.85	78.58	74.30	2.47	71.45	77.41
75.47	3.18	71.90	80.52	77.10	2.97	73.28	80.41
77.82	2.83	74.86	83.46	79.19	3.15	75.45	83.10
79.41	2.70	76.69	84.41	80.89	3.24	76.87	84.23
41.61	2.32	37.66	44.16	42.25	1.51	40.20	43.71
42.14	2.40	38.63	45.20	43.23	0.86	41.95	43.67
42.56	2.73	38.29	45.95	43.45	0.57	42.99	44.21
42.52	3.05	38.21	46.73	43.81	1.11	42.20	44.69
42.55	3.19	37.75	46.80	43.75	1.36	42.09	45.41
43.43	1.72	40.60	45.94	45.06	1.50	43.74	47.20
43.64	1.91	40.21	45.47	44.72	1.04	43.77	45.82
43.98	2.36	39.12	45.87	44.74	0.12	44.57	44.83
44.21	2.62	39.33	46.99	44.95	0.65	44.07	45.58
44.10	3.05	38.23	47.84	44.82	1.14	44.14	46.51
−1.82	2.67	−8.28	0.41	−2.80	1.85	−5.07	−1.09
−1.50	2.27	−6.75	0.94	−1.48	0.93	−2.15	−0.11
−1.42	1.89	−5.82	0.24	−1.29	0.66	−1.82	−0.36
−1.70	1.75	−5.67	−0.26	−1.14	0.55	−1.87	−0.58
−1.55	1.95	−5.87	−0.09	−1.07	0.75	−2.05	−0.24

where the molar differences in the Class II/1 groups were caused by a narrower maxillary intermolar width.

Finally, the limitations of this study, particularly, the small sample size in the Class II/2 subgroup, must be acknowledged. Sample size restrictions also prevented further subgroup analysis, eg, a consideration of Class II subgroups with different arch morphologies as described by Fröhlich[19] or Karlsen,[41] or a separate analysis of patients with or without crossbites.

In summary, the present study confirms in Class II cases a close association between anteroposterior malocclusion and the transverse dimensions both of the maxillary skeletal base and the maxillary dental arch. This relationship between the transverse and the anteroposterior dimensions has already been discussed in previous studies. Staley et al[21] assumed a narrower upper arch as a result of mandibular retrognathism. They mentioned that in a Class II relationship, the buccal overjet increases because of the posterior displacement of the mandible. Subsequently, a compensatory mechanism, ie, a palatal movement of the upper posterior teeth, was assumed, which reduces buccal overjet, thus achieving a better buccolingual interdigitation. Tollaro et al,[23] in turn, emphasized that the presence of a primitive transverse discrepancy between dental arches induces a backward position of the mandible. They pointed out that in Class II cases with a molar difference, a spontaneous repositioning of the mandible may take place after a preliminary expansion of the maxillary arch and that mandibular growth should possibly be stimulated by means of a functional forward guidance of the mandible. Similarly, Bishara et al[24] suggested an early transverse maxillary correction within the Class II treatment plan if there exists a transverse discrepancy. Finally, it should be emphasized that because of the large individual variation encountered, all findings present tendencies rather than general growth laws. Nevertheless, the clinician should be aware of the relationship between transverse and sagittal anomalies and as a consequence pay attention to transverse interarch discrepancies in the diagnostic process of Class II malocclusions, eg, by a determination of molar differences or comparable measurements of interarch discrepancies. In addition,

TABLE 4. Intergroup Comparisons Between the Four Groups, Separately for Boys and Girls (I = Class I group, GO = good-occlusion group, II/1, II/2 = Class II/1, Class II/2 groups). Only *P* Values ≤.10 are Depicted. Significant *P* Values (*P* ≤ .01) are Marked by an Asterisk

		Boys					Girls				
Variable	Age	I vs II/1	I vs II/2	II/1 vs II/2	GO vs II/1	GO vs II/2	I vs II/1	I vs II/2	II/1 vs II/2	GO vs II/1	GO vs II/2
Skeletal widths											
Maxillary skeletal base width	7	.059	—	—	.004*	—	.015	—	—	.039	—
	9	.041	—	—	.002*	.056	.017	—	.076	.024	—
	11	.021	—	—	.001*	.056	.017	—	.076	.075	—
	13	.024	—	.083	<.001*	.029	.060	—	—	.092	—
	15	.002*	—	.031	<.001*	.019	.029	—	—	.075	—
Bigonial width	7	—	—	—	—	—	—	—	—	.092	—
	9	—	—	—	—	—	—	—	—	—	—
	11	—	—	—	—	—	—	—	—	—	—
	13	—	—	—	—	—	—	—	—	—	—
	15	—	—	—	—	—	—	—	—	.092	—
Biantegonial width	7	—	—	—	—	—	—	—	—	—	—
	9	—	—	—	—	—	—	—	—	—	—
	11	—	—	—	—	—	.085	—	—	.039	—
	13	—	—	—	—	—	—	—	—	—	—
	15	—	—	—	—	—	—	—	—	.049	—
Intermolar widths											
Maxillary intermolar width	7	.024	—	—	.003*	—	.006*	.061	—	.005*	.041
	9	.014	—	—	.002*	.069	.011	.055	—	.018	.034
	11	.006*	—	—	.002*	.075	.005*	.024	—	.007*	.051
	13	.009*	—	.031	.002*	.083	.010*	.097	—	.010*	.051
	15	.016	—	.005*	.002*	.083	.010*	.067	—	.014	.075
Mandibular intermolar width	7	—	—	—	—	—	.090	—	—	—	—
	9	—	—	—	.046	—	.037	—	—	.052	—
	11	—	—	—	.056	—	.021	.097	—	.066	.051
	13	—	—	—	.069	—	.055	—	—	.066	—
	15	—	—	.083	.056	—	—	—	—	—	—
Molar difference	7	.031	.056	—	.011	.006*	.032	.007*	—	—	.022
	9	.017	.075	—	.004*	.029	—	.067	—	—	.075
	11	.028	—	—	.007*	—	.013	.019	—	.031	.027
	13	.002*	.004*	—	.002*	.005*	.007*	.037	—	.007*	.034
	15	<.001*	.010*	—	<.001*	.007*	.006*	.024	—	.014	.051

the morphological characteristics depicted in the various types of malocclusions may serve as additional determinants when choosing suitable treatment strategies for transverse anomalies as well as in borderline cases between extraction and nonextraction treatment. In that context, the present study supports the results of Alarashi et al,[26] who found a skeletal constriction of the maxilla in Class II malocclusions also and concluded that a rapid palatal expansion might be the treatment of choice in such cases.

CONCLUSIONS

- Maxillary skeletal base widths were smallest in the Class II/1 groups and largest in the Class I and good-occlusion groups in both sexes. At age 15 years, differences between the Class II/1 and the Class I groups were statistically significant among the boys. No statistically significant differences were found for bigonial and biantegonial widths.
- Maxillary intermolar widths were smaller in the Class II/1 group than in the Class I and the good-occlusion groups, both in boys and girls. This difference was found during the total period of observation, ie, from seven to 15 years, and was statistically significant at most ages. In mandibular intermolar widths, the Class II/1 cases were also slightly smaller than the control groups, but group differences were statistically not significant.
- The Class II/1 groups exhibited the largest molar differences, which were about −2.5 mm among the boys and −1.5 to −2 mm among the girls. Differences between the Class II/1 and the Class I groups were statistically significant at 13 and 15 years in both sexes. Hence, in the Class II/1 subjects the deviations in molar differences observed at 15 years of age were established already at 7 years of age (or before) and maintained during 7 and 15 years of age. In the Class II/2 groups, smaller mean molar differences were found; group differences between

the Class I and the Class II/2 subjects were, however, statistically significant at 13 and 15 years among the boys.

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