Maxillary and Mandibular Dental-Arch Dimensions and Occlusion in Bilateral Cleft Lip and Palate Patients from 3 to 17 Years of Age

KIKI L.W.M. HEIDBUCHEL, D.D.S.
ANNE MARIE KUIJPERS-JAGTMAN, D.D.S., PH.D.

The aim of this study was to describe maxillary and mandibular dental-arch form and occlusion in bilateral cleft of the lip and palate (BCLP) from 3 to 17 years of age and to compare their characteristics with a normative sample. A sample of 22 patients with BCLP was investigated, with a noncleft control sample used for comparison. Dental-arch dimensions were studied on dental casts. A comparison between both groups was made at fixed time intervals. From 9 years of age, the cleft sample showed a significantly smaller maxillary depth. Maxillary dental-arch widths were also significantly smaller than in the control group over the whole age period. Mandibular dental-arch measurements were very similar in both groups, although smaller first-molar widths were noted in the BCLP group beginning at 12 years of age. A tendency for end-to-end occlusion was found, which became more clear with age and was most markedly in the canine region.

KEY WORDS: *bilateral cleft lip and palate, dental arch, dental occlusion*

The treatment of children with a cleft lip and palate remains a challenge. Beginning at birth, it is necessary to balance several aspects of treatment such as growth, esthetics, function, and psychosocial development. In children with a complete bilateral cleft lip and palate, many problems remain unresolved. Apart from intrinsic tissue deficiency and anatomic aberrations, there is difficulty in restoring the orbicularis oris muscle, in creating a philtrum, and in lengthening the columella. Furthermore, benefit of early orthopedic treatment is still questioned. Unrestricted premaxillary growth also gives rise to many problems. Finally, the influence of surgery on further growth and stability after treatment are topics that need to be investigated in more detail (Bishara and Olin, 1972; Ross and Johnston, 1972; Banks, 1983; Hayward, 1983; Vargervik, 1983; Freihofer et al., 1991; Bardach et al., 1992; Heidbuchel et al., 1993; Friede and Lilja, 1994; Heidbuchel et al., 1994).

The relatively low incidence (about 0.3/1000 live births) of children with a bilateral cleft of the lip and palate (BCLP) explains why there is limited information concerning dentofacial variability and treatment outcome in BCLP. With respect to dental-arch dimensions and occlusion in BCLP patients, only a few longitudinal studies with a sufficient number of patients can be found in the literature (Larson et al., 1983; Bishara et al., 1985; Athanasiou et al., 1987; Friede et al., 1987; Hotz et al., 1987).

Larson et al. (1983) evaluated the dental occlusion in the deciduous dentition of 19 children with bilateral clefts who underwent orthopedic treatment and early bone grafting before orthodontic treatment and after starting orthodontic treatment (about 10 years of age). A comparison was made to a noncleft group. The BCLP group showed a significantly higher frequency of mesio-occlusion. For overbite and overjet, no significant differences were found in deciduous dentition. In the mixed dentition, however, the BCLP group had a smaller overjet and overbite as well as a narrower maxillary dental arch in the canine region.

In a study of unoperated clefts by Bishara et al. (1985), the BCLP group showed smaller dental-arch widths than a control group. Since only seven dental casts taken at four different ages (between 7 and 51 years of age) were available, no firm conclusions could be reached. Athanasiou et al. (1987) studied dental-arch dimensions between 3 and 12 years of age in 11 children. Maxillary interdental widths were significantly smaller for all ages compared to noncleft individuals. Maxillary length was not significantly smaller. Mandibular-arch dimensions seemed to be affected by the changes in the maxillary arch.

Friede et al. (1987) studied two different treatment approaches concerning hard palate closure in 15 BCLP patients. Due to the relatively large variation in maxillary morphology and the small number of patients studied, no differences in facial morphology and occlusion between subgroups could be found. Hotz et al. (1987) evaluated early orthopedic treatment in combination with a two-stage lip repair of 14 consecutive BCLP cases at the 10-year age level. An average decrease of 4 to 5 mm in anterior-arch length between birth and age 10 was found. The premaxillary overjet relative to the mandible

---

Dr. Heidbuchel is in the Department of Orthodontics (Head Professor C. Carels), University Hospital of Leuven, Leuven, Belgium. Dr. Kuijpers-Jagtman is Professor and Chair, Department of Orthodontics and Oral Biology, University of Nijmegen, and Director of the Cleft Palate Center, University Hospital of Nijmegen, Nijmegen, The Netherlands.

Submitted November 1995; Accepted August 1996.

Reprint requests: Dr. A.M. Kuijpers-Jagtman, University of Nijmegen, Department of Orthodontics and Oral Biology, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands.

spontaneously decreased from an average of 13 mm at birth to an average of 3 mm at age 10.

Because of the lack of published data on dental-arch dimensions in complete BCLP, it was our aim to study occlusion and arch dimensions in a BCLP group treated in one cleft lip and palate center, according to a strict treatment protocol, from 3 to 17 years of age, and to compare the variables with those of noncleft individuals.

METHODS

For this study, mixed longitudinal records of 22 patients (15 boys, 7 girls) born between 1966 and 1981 with no known anomaly or syndrome other than a complete bilateral cleft lip, alveolus, and palate, were used. They were all treated at the Cleft Palate Center of the University Hospital of Nijmegen, The Netherlands, according to a strictly defined treatment plan (Table 1). About 50% of the cases received presurgical orthopedic treatment, as described by Hotz and Gnoinski (1976). Extra-oral strapping was used until lip closure. Afterward, the acrylic appliance was worn as a retention device until the soft palate was closed. A one-stage cheiloplasty [modified Manchester technique (Manchester, 1970)] was performed at about 3 months of age; closure of the soft palate according to Von Langenbeck at the age of 18 months; and closure of the hard palate at about 4 years of age or later in combination with alveolar bone grafting. All cases in this study underwent an osteotomy of the premaxilla in combination with early secondary alveolar bone grafting. Two thirds of the patients needed orthodontic expansion before the osteotomy. Afterward, fixed appliances were necessary to align the dental arches.

Between 2 and 13 dental casts were available for each patient, which made a total of 149 dental casts. The Optocom (Van der Linden et al., 1972) was used for digitizing 112 mandibular and maxillary dental landmarks, as proposed by Moorrees (1959) (Fig. 1), and their coordinates were computerized. Dental-arch dimensions were calculated from the coordinates, and their means, standard deviations, and ranges were computed for each age.

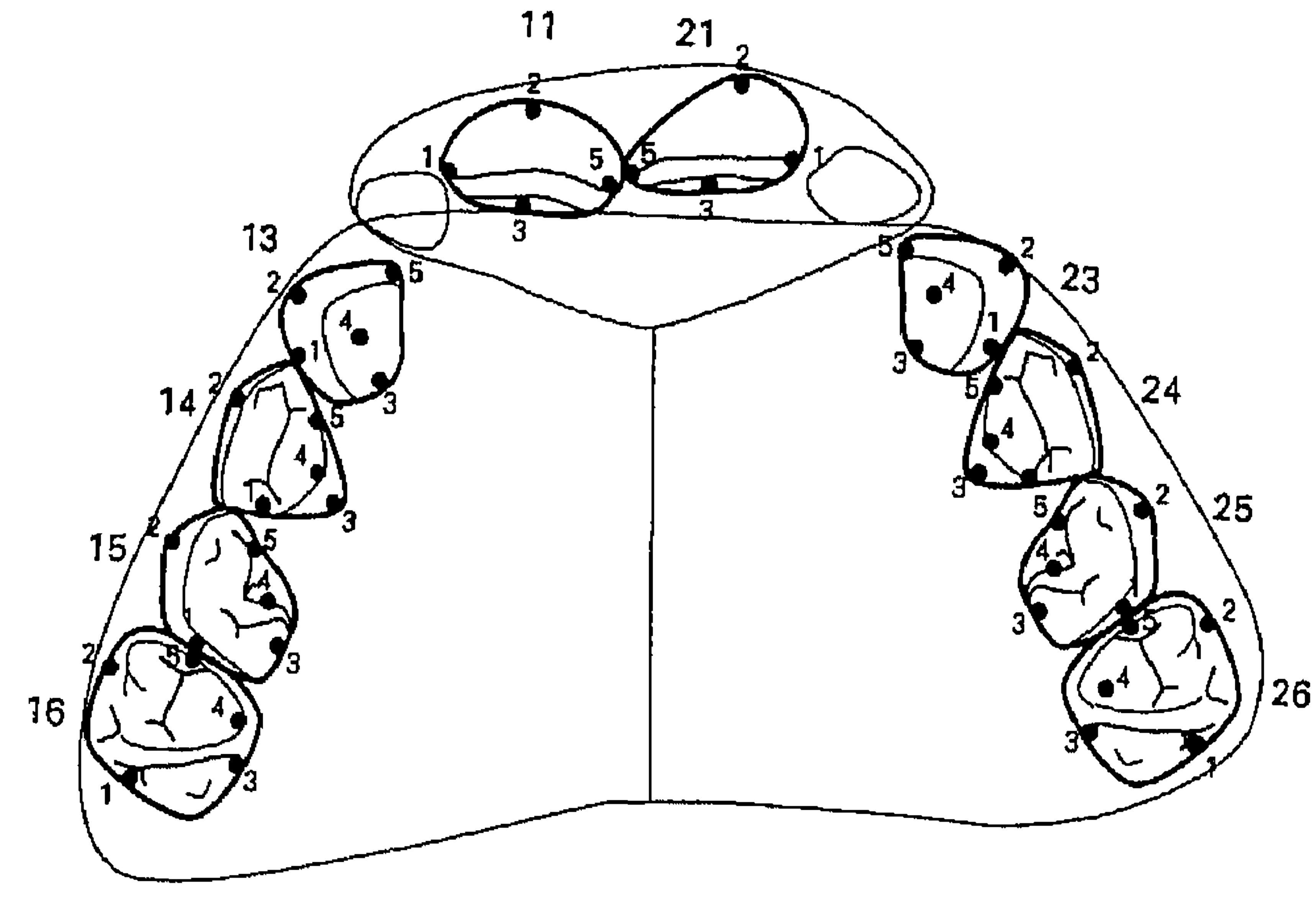

FIGURE 1 **Points digitized on dental casts. 1: distal anatomic contact point; 2: most buccal point; 3: most palatal point; 4: mesio-palatal cusp point of molars and deciduous molars, cusp of canines; 5: mesial anatomic contact point.**

The control group consisted of 253 dental casts of 42 noncleft children (27 boys and 15 girls), collected by Prof. Leighton (Kings College Hospital, London). These children showed a normal occlusion with limited or no crowding and no loss of teeth. From each child, six to seven casts taken at fixed time intervals were available. Digitizing and calculation of distances was performed as described for the BCLP group.

Distances that were calculated are illustrated in Figure 2. Maxillary as well as mandibular-arch dimensions were determined. Arch widths were measured between the midpoints of left and right canines, premolars, deciduous molars, and first permanent molars. These midpoints were defined as half of the distance between mesial and distal anatomic contact points. Arch depth was measured between the mesial points

TABLE 1 **Orthodontic and Surgical Treatment Strategy of BCLP Patients at the Nijmegen Cleft Palate Center**

Birth	Presurgical orthopedics (Hotz)
3 mo	One-stage lip closure (modified Manchester)
	End of active orthopedics
18 mo	Posterior palate closure (modified von Langenbeck)
	End of retention period with intraoral plates
4 yr	Hard palate closure (before 1975)
5–6 yr	Columella lengthening
	Lip mucosa and skin scar revision
	Superior-based pharyngeal flap
8 yr	Orthodontic correction of incisor tooth position and correction of transverse segmental crossbites
9 yr	Osteotomy of premaxilla in combination with bone grafting and hard palate closure (after 1975)
12 yr	Orthodontic finishing
15 yr	Secondary lip and nose revision
18 yr	Osteotomy of the maxilla and/or mandible (if necessary)

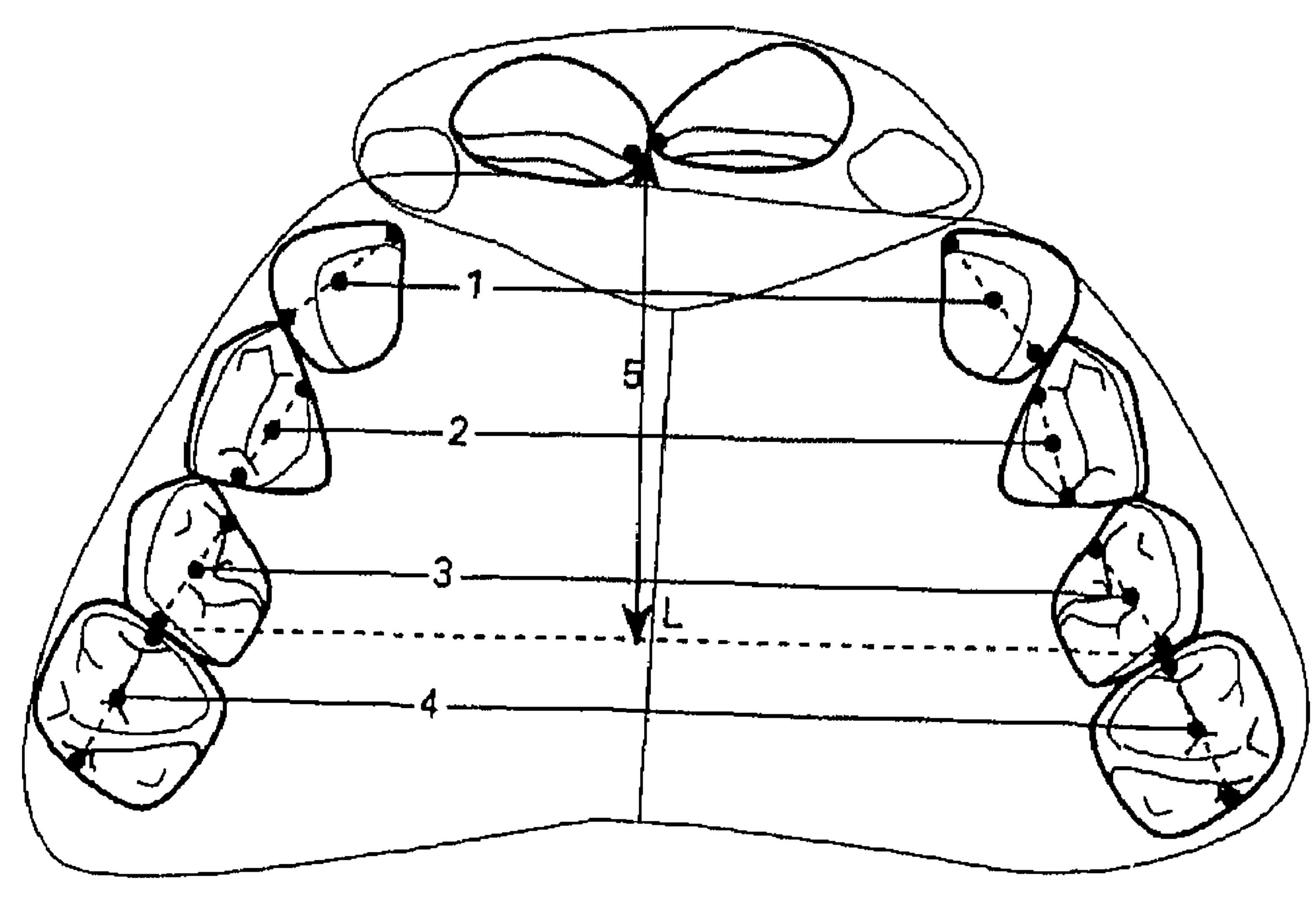

FIGURE 2 **Measured distances: arch widths (1–4) between midpoints of molars, premolars, deciduous molars, and canines; arch depth (5) from midpoint of first molars (mesial anatomic contact point) to contact point of central incisors.**

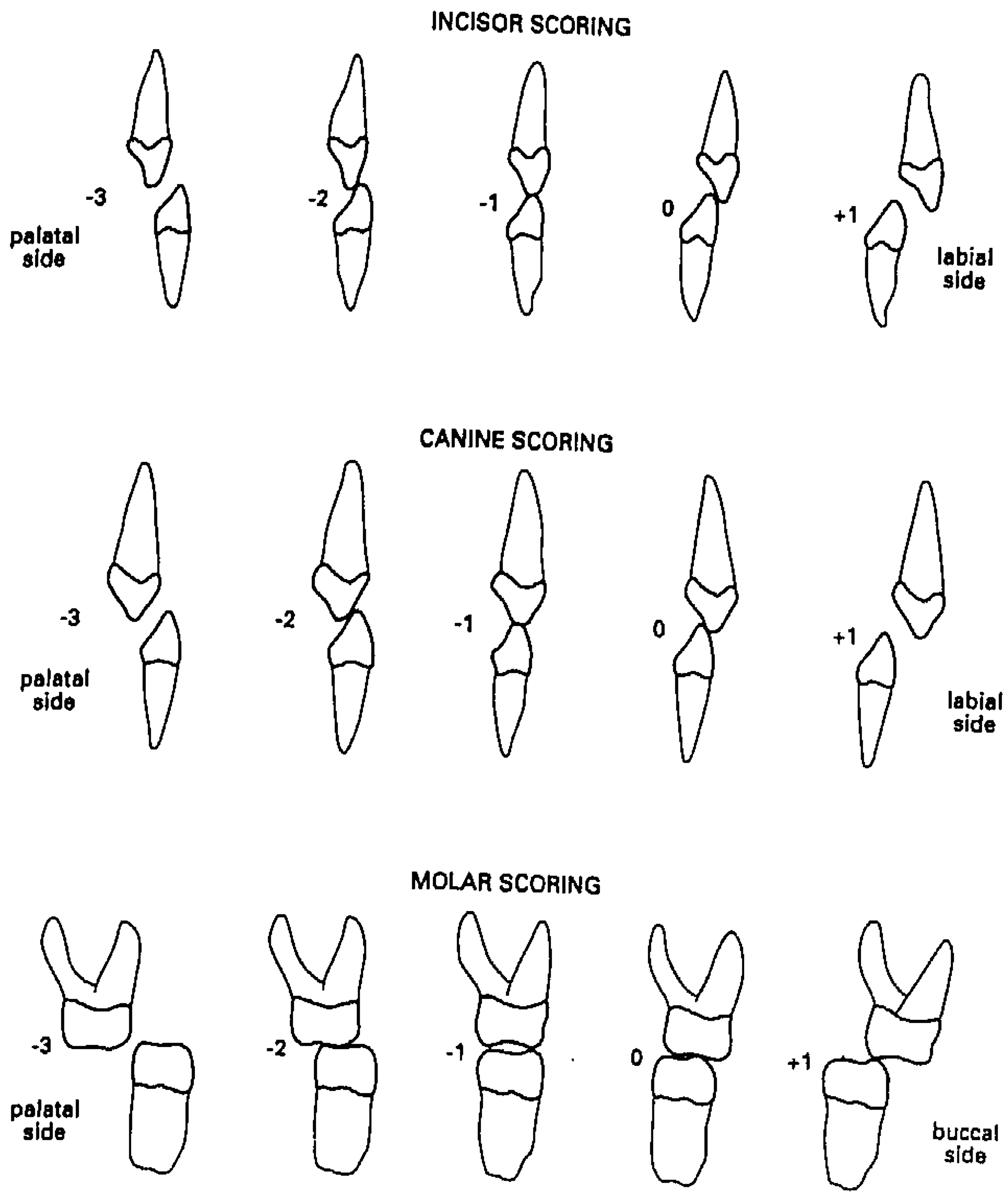

FIGURE 3 **Huddart's scoring of buccolingual dental relationship.**

of the two central incisors (or the midpoint of the central diastema) and the midpoint of a line extending from the mesial anatomic contact point of left to the right first molars. Twenty randomly selected dental casts, covering the full age range, were digitized twice by the same person to compute measurement error.

The mean values of the control group were interpolated for eight different ages (i.e., 3, 4, 5, 6, 9, 12, 16, and 17 years). The difference between the interpolated value and the nearest age period did not exceed 1.5 years. Extrapolation was not applied. At these ages, a two-way ANOVA was conducted to determine whether or not the mean value in the two

TABLE 2 **Results of Interobserver Reproducibility**

Measurement	*Error*	*Measurement/Remeasurement Correlation*
Maxillary arch depth	0.25 mm	.98
Mandibular arch depth	0.17 mm	.88
Maxillary canine width	0.13 mm	.99
Maxillary first premolar width	0.15 mm	.97
Maxillary second premolar width	0.10 mm	.99
Maxillary first molar width	0.21 mm	.97
Mandibular canine width	0.12 mm	.99
Mandibular first premolar width	0.23 mm	.98
Mandibular second premolar width	0.15 mm	.99
Mandibular first molar width	0.27 mm	.99
Overjet	1.0 mm	.94
Overbite	0.7 mm	.95
Angle classification	0.25 Pm width	.81
Midline deviation	1.1 mm	.75
Huddart score (see Fig. 3)	0.5 points	.82

TABLE 3 **Maxillary Arch Depth**

	BCLP		*Control*		
Age	*n*	*Mean (mm) ± SD*	*n*	*Mean (mm) ± SD*	*p Value*
3	6	29.8 ± 3.4	28	28.7 ± 1.4	.22
4	8	27.5 ± 5.7	39	28.2 ± 1.6	.58
5	10	27.4 ± 4.9	39	27.2 ± 1.7	.81
6	10	26.8 ± 4.8	39	27.6 ± 1.7	.41
9	11	26.2 ± 4.4	37	29.0 ± 2.1	.00*
12	15	23.1 ± 4.5	36	28.7 ± 2.4	.00*
16	12	20.7 ± 4.0	28	27.7 ± 2.4	.00*
17	11	20.8 ± 3.3	25	27.3 ± 2.5	.00*

significance: *$p < .05$.

groups differed significantly from each other and to assess gender differences.

In addition, Huddart's scoring system (Huddart and Bodenham, 1972), slightly modified, was used to evaluate the severity and location of crossbites. Scores, as described in Figure 3, were recorded by two independent orthodontists. The lateral incisors were not assessed as they are often absent in BCLP patients. Each tooth was given a score depending on its position relative to the lower arch.

Finally, midline deviation, overjet, and overbite, and the sagittal molar and canine occlusion according to the Angle classification were measured by the same two examiners. Overjet and overbite were measured relative to each of the two maxillary central incisors. Afterward, a mean value of the two scores was calculated. The one sample t test was used to compare the dental occlusion of the BCLP group to the norms from Huddart's scoring system (0), midline deviation (0), overjet (2), overbite (2), and sagittal molar and canine occlusion (0) for both sexes together.

RESULTS

Measurement errors are given in Table 2. Measurement errors of the distances varied between 0.10 and 0.27 mm, which was considered acceptable. For overjet, overbite, and midline deviation, the measurement error was about 1 mm. The measurement errors for the Angle classification and Huddart scoring were small. All measurement/remeasurement correlations reached an acceptable level (see Table 2).

TABLE 4 **Mandibular Arch Depth**

	BCLP		*Control*		
Age	*n*	*Mean (mm) ± SD*	*n*	*Mean (mm) ± SD*	*p Value*
3	6	24.6 ± 1.3	31	25.2 ± 1.4	.20
4	9	24.3 ± 1.3	41	25.0 ± 1.6	.07
5	10	24.1 ± 1.1	41	24.7 ± 1.6	.07
6	11	24.1 ± 1.2	40	24.6 ± 1.8	.20
9	14	24.1 ± 2.5	38	24.6 ± 2.2	.41
12	14	22.8 ± 1.9	36	23.9 ± 2.4	.16
16	13	21.2 ± 1.9	28	23.1 ± 2.1	.00*
17	12	21.2 ± 2.2	25	22.6 ± 2.1	.06

significance: * $p < .05$.

TABLE 5 Maxillary Canine Width

	BCLP		Control		
Age	n	Mean (mm) ± SD	n	Mean (mm) ± SD	p Value
3	6	24.9 ± 3.1	39	27.9 ± 1.4	.00*
4	9	25.0 ± 2.6	41	27.9 ± 1.5	.00*
5	10	25.5 ± 2.6	41	28.1 ± 1.7	.00*
6	11	25.5 ± 3.2	40	28.6 ± 1.8	.00*
9	14	24.6 ± 3.4	36	30.9 ± 2.0	.00*
12	16	23.1 ± 3.2	35	32.2 ± 1.9	.00*
16	11	22.9 ± 3.9	28	32.7 ± 1.8	.00*
17	11	22.7 ± 3.4	25	32.4 ± 1.8	.00*

significance:* $p < .05$.

TABLE 7 Mandibular Canine Width

	BCLP		Control		
Age	n	Mean (mm) ± SD	n	Mean (mm) ± SD	p Value
3	6	22.9 ± 0.9	38	22.4 ± 1.1	.42
4	9	22.6 ± 1.1	42	22.6 ± 1.2	.66
5	9	22.8 ± 1.1	42	22.9 ± 1.3	.73
6	10	23.4 ± 1.0	40	23.4 ± 1.4	.89
9	12	24.7 ± 1.6	37	25.4 ± 1.4	.09
12	15	23.7 ± 1.9	35	25.6 ± 1.4	.00*
16	12	24.6 ± 2.0	28	25.3 ± 1.4	.21
17	12	24.3 ± 1.9	25	25.0 ± 1.4	.21

significance:* $p < .05$.

Significant gender differences were not observed for the arch dimensions. Between 3 and 6 years of age, no significant difference in maxillary arch depth between BCLP cases and control individuals was found. From 9 years of age on, upper-arch depth became significantly smaller in BCLP cases than in the control group (Table 3). In the mandible, differences in arch depth between groups were small (Table 4).

The BCLP group demonstrated significantly smaller maxillary dental-arch widths than the control group over the entire experimental period. Instead of an increase observed in the control group, a decrease of arch width appeared in the BCLP group. The proportional difference was the greatest in the canine region: at 3 years of age, the mean canine width in the BCLP group was only 11% smaller, but at 17 years of age, it was 30% narrower than in the control group (Table 5). The width between the first molars was 7% smaller at 6 years of age and 17% at 17 years of age (Table 6).

Concerning the mandibular arch widths, both groups followed the same pattern, although the BCLP group showed significantly smaller intermolar distances from 12 years of age on (Tables 7 and 8).

No significant differences could be found between mean Huddart's scores and normal values for the central incisors. The mean canine-crossbite scores varied between −0.7 and −1.2 and were statistically different from normal. Molars showed slightly negative Huddart's scores over the whole period of age (Table 9).

For sagittal canine and molar occlusion, scores became more positive with age, which tended to disto-occlusion (Table 10). Overjet diminished from 4.1 mm at 3 years of age to −0.4 mm at 14 years of age, which differed significantly from normal. At 17 years of age, a mean overjet of 1.6 mm was reached, which was no longer statistically different. Overbite was positive in the beginning but ended slightly negative (open bite) with a mean value of −0.3 mm at 17 years of age. A midline deviation was apparent between 3 and 10 years of age, but disappeared completely by 16 years of age (Table 11).

Discussion

Although the results show several significant differences between the BCLP group and the noncleft individuals, the small number of children studied allows only cautious interpretation of these results. Also, gender differences were not frequently noticed. It is probable that they were masked by the large variation of arch dimensions in the cleft group.

In this study, we found that from 9 years of age on, maxillary dental arch depth was smaller than in the control group. Perhaps the orthodontic expansion, which is typically performed at 8 years of age, allowed the premaxilla to move more palatally. A palatoversion of the maxillary central incisors or a mesiodisplacement of the first molars can also cause smaller upper-arch-depth values. However, in a previous cephalometric investigation of the same group of patients, we found an uprighting of the upper front teeth after osteotomy of the premaxilla (Heidbuchel et al., 1993). In some cases, first maxillary molars were moved mesially to close the dental arch anteriorly. Since agenesis of lateral incisors is frequently seen in BCLP patients, this anterior closing is very common during treatment. Hotz et al. (1987) also found a diminishing in

TABLE 6 Maxillary First-Molar Width

	BCLP		Control		
Age	n	Mean (mm) ± SD	n	Mean (mm) ± SD	p Value
6	2	40.9 ± 3.5	4	44.9 ± 1.9	.34
9	12	41.6 ± 3.0	29	45.1 ± 1.7	.00*
12	17	40.0 ± 3.5	33	46.8 ± 2.1	.00*
16	13	40.0 ± 3.4	27	47.8 ± 2.4	.00*
17	12	39.8 ± 2.7	25	47.8 ± 2.6	.00*

significance:* $p < .05$.

TABLE 8 Mandibular First-Molar Width

	BCLP		Control		
Age	n	Mean (mm) ± SD	n	Mean (mm) ± SD	p Value
6	4	40.3 ± 4.2	2	43.4 ± 3.0	.35
9	10	41.1 ± 2.8	31	42.4 ± 1.8	.10
12	15	40.6 ± 2.7	34	42.9 ± 1.9	.00*
16	12	41.1 ± 3.3	28	43.4 ± 2.3	.01*
17	11	41.2 ± 3.5	25	43.3 ± 2.5	.04*

significance:* $p < .05$.

TABLE 9 Huddart Scores: Central Incisor, Canine, and First-Molar Occlusion

	Central Incisors			Canines			Molars		
Age	*n*	*Mean ± SD*	*t Value*	*n*	*Mean ± SD*	*t Value*	*n*	*Mean ± SD*	*t Value*
3	10	0.2 ± 1.6	0.46	10	−0.8 ± 1.0	−2.08*			
6	10	0.6 ± 1.2	1.38	10	−0.7 ± 1.0	−1.82	9	−0.4 ± 0.8	−1.00
8	10	−0.5 ± 1.4	−1.15	11	−1.2 ± 1.2	−3.27**	10	−0.2 ± 0.6	−0.50
10	15	−0.1 ± 1.6	−0.28	13	−1.2 ± 1.2	−3.55**	11	−0.1 ± 0.4	−1.10
12	14	−0.0 ± 1.2	0.00	14	−0.7 ± 1.4	−2.15*	14	−0.2 ± 0.5	−3.74**
14	11	−0.0 ± 1.2	0.00	9	−1.1 ± 1.3	−2.71**	16	−0.6 ± 0.8	−2.00*
16	12	−0.6 ± 1.4	−1.52	11	−1.0 ± 1.3	−2.72**	11	−0.2 ± 0.5	−0.55
17	8	−0.5 ± 1.2	−1.03	9	−0.9 ± 1.2	−2.22*	11	−0.3 ± 0.9	−3.87**

significance: *t < .05.
** t < .01.

upper–dental-arch length up to the age of 10 years. Athanasiou et al. (1987) suggested that the maxillary arch length in the BCLP patient group was not significantly smaller than in the control group during the primary and mixed dentition, but at the age of 12 years, it even increased more than in the control group. Perhaps prosthetic replacement of absent lateral incisors was the treatment of choice here. This can explain the different treatment results.

Concerning arch widths, smaller arches were found in BCLP patients from 3 years of age on. Similar findings were found in earlier investigations (Larson et al., 1983; Bishara et al., 1985; Athanasiou et al.,1987). Several reasons for this transverse underdevelopment of the maxilla have been reported: maxillary tissue deficiency (Huddart and Bodenham, 1985), intrinsic developmental deficiency (Ross and Johnston, 1972), and collapse of the alveolar arch following lip and palate surgery (Rune et al., 1980). Although an orthodontic expansion of the lateral segments has been performed in two thirds of our patients, the proportional difference between noncleft and BCLP widths became larger with age, and Huddart scores remained slightly negative. This can be attributed to further segmental movements, as seen by Rune et al. (1980), or to relapse after expansion and premaxilla osteotomy. Toward the end of the treatment, narrowing of upper-arch widths can also be attributed to orthodontic anterior-space closure of the maxillary dental arch.

TABLE 10 Sagittal Canine and Molar Occlusion

	Canine			Molar		
Age	*n*	*Mean ± SD*	*t Value*	*n*	*Mean ± SD*	*t Value*
3	10	0.2 ± 0.4	1.27			
6	10	0.6 ± 0.5	3.82**	9	0.4 ± 0.5	2.77**
8	11	0.4 ± 0.5	2.67**	11	0.4 ± 0.4	3.06**
10	13	0.4 ± 0.4	2.90**	16	0.4 ± 0.4	3.70**
12	14	0.6 ± 0.7	4.51**	15	0.5 ± 0.4	4.47**
14	9	0.6 ± 0.4	3.62**	11	0.6 ± 0.4	4.60**
16	11	0.6 ± 0.5	4.00**	12	0.6 ± 0.5	4.80**
17	9	0.6 ± 0.4	3.62**	7	0.6 ± 0.6	3.67**

significance: *t < .05.
** t < .01.

Mandibular-arch dimensions in BCLP and controls are very similar. A slight decrease in arch width is noticed beginning at 12 years of age. This was also noted by Athanasiou et al. (1987). This means that the mandibular dental arch seems to adapt to smaller maxillary widths.

To analyze transverse dental occlusion, the Huddart scoring system was chosen because the reliability and consistency of this method is greater than a descriptive classification. Furthermore, the severity of crossbite is also taken into account, and it is easier to assess statistically (Huddart and Bodenham, 1972). The results of transverse occlusion were in accordance with the transverse distance measurements between canines and molars.

At the end of treatment, mean overbite became negative, which represents an open bite tendency. Larson et al. (1983) found that the overbite also diminished in the mixed dentition. After an inherent growth aberration at the premaxillary region, the osteotomy of the premaxilla, which was performed in all cases of this study, could have reinforced an open bite tendency. In a previous investigation, we found that it is difficult to lower a high-positioned premaxilla by osteotomy (Heidbuchel et al., 1993). This may explain why the mean overbite became more negative, or, in other words, that the premaxilla always ends in a higher position after osteotomy. Finally, it was remarkable to measure a midline deviation at an early age, despite a one-step lip closure, but this asymmetry had disappeared by the end of treatment.

It can be concluded that at the early ages, the differences between BCLP and noncleft controls are small. By the age of 7 years, differences become more obvious: maxillary arch depth and width as well as overjet and overbite diminish in comparison to the controls. At the end of the treatment at 17 years of age, a slight disto-occlusion and transverse end-to-end occlusion (which is most apparent at the canine region) is present. It should be stressed, however, that this study only gives a global description of dental development in a relatively small, but well-defined BCLP group with a specific treatment protocol and that this has to be superimposed on an individual development that shows a large variation.

TABLE 11 Midline Deviation, Overjet, and Overbite

	Overjet			Overbite			Midline Deviation		
Age	n	Mean (mm) ± SD	t Value	n	Mean (mm) ± SD	t Value	n	Mean (mm) ± SD	t Value
3	10	4.1 ± 4.0	1.88	10	1.4 ± 2.0	−0.70	10	1.7 ± 2.2	2.69**
6	9	3.8 ± 3.8	1.53	9	1.3 ± 3.4	−0.77	10	0.7 ± 2.5	1.11
8	10	1.6 ± 3.5	−0.36	10	0.5 ± 3.3	−1.74	11	1.4 ± 1.6	2.32*
10	15	0.6 ± 4.0	−1.53	15	1.6 ± 3.4	−0.57	16	1.2 ± 2.3	2.40*
12	14	1.1 ± 3.3	−0.95	14	0.6 ± 2.7	−1.92	14	0.7 ± 2.1	1.31
14	11	−0.4 ± 3.6	−2.25*	11	0.2 ± 1.6	−2.19*	11	0.1 ± 1.7	0.17
16	12	0.3 ± 3.1	−1.67	12	1.5 ± 2.7	−0.64	13	0.0 ± 1.7	0.00
17	8	1.6 ± 2.4	−0.32	8	−0.3 ± 1.4	−2.39*	10	0.0 ± 1.6	0.00

significance: * $t < .05$.
** $t < .01$.

Acknowledgments. The authors thank Prof. Leighton (Kings College Hospital, London) for the use of his longitudinal data set of dental casts. We also thank Dr. M. Van 't Hof, biostatistician, Mrs. A. Derycke, and Mr. S. Nottet for their patience, advice, and help.

References

Athanasiou AE, Mazaheri M, Zarrinnia K. Longitudinal study of the dental arch dimensions in bilateral cleft lip and palate patients. J Pedodont 1987;11:253–268.

Banks P. The surgical anatomy of secondary cleft lip and palate deformity and its significance in reconstruction. Br J Oral Surg 1983;21:78–93.

Bardach J, Morris HL, Olin WH, et al. Results of multidisciplinary management of bilateral cleft lip and palate at the Iowa cleft palate center. Plast Reconstr Surg 1992;89:419–435.

Bishara SE, Martinez RS, Patron Vales H. Dentofacial relationships in persons with unoperated clefts: comparisons between three cleft types. Am J Orthod 1985;88:481–507.

Bishara SE, Olin WH. Surgical repositioning of the premaxilla in complete bilateral cleft lip and palate. Angle Orthod 1972;42:139–147.

Freihofer HPM, Van Damme PA, Kuijpers-Jagtman AM. Early osteotomy—stabilization of the premaxilla in bilateral clefts. J Craniomaxillofac Surg 1991;19:2–6.

Friede H, Lilja J. Dentofacial morphology in adolescent or early adult patients with cleft lip and palate after a treatment regimen that included vomer flap surgery and pushback palatal repair. Scand J Plast Reconstr Surg 1994;28:113–121.

Friede H, Möller M, Lilja J, Lauritzen C, Johanson B. Facial morphology and occlusion at the stage of early mixed dentition in cleft lip and palate patients treated with delayed closure of the hard palate. Scand J Plast Reconstr Surg 1987;21:65–71.

Hayward JR. Management of the premaxilla in bilateral cleft lip and palate. J Oral Maxillofac Surg 1983;41:518–524.

Heidbuchel KLWM, Kuijpers-Jagtman AM, Freihofer HPM. An orthodontic and cephalometric study on the results of the combined surgical-orthodontic approach of the protruded premaxilla in bilateral clefts. J Craniomaxillofac Surg 1993;21:60–66.

Heidbuchel KLWM, Kuijpers-Jagtman AM, Freihofer HPM. Facial growth in patients with bilateral cleft lip and palate. A cephalometric study. Cleft Palate Craniofac J 1994;31:1–7.

Hotz M, Gnoinski W. Comprehensive care of cleft lip and palate children at Zurich University. A preliminary report. Am J Orthod 1976;70:481–503.

Hotz M, Perko M, Gnoinski W. Early orthopedic stabilization of the premaxilla in complete bilateral cleft lip and palate in combination with the celesnik lip repair. Scand J Plast Reconstr Surg 1987;21:45–51.

Huddart AG, Bodenham RS. The evaluation of arch form and occlusion in unilateral cleft palate subjects. Cleft Palate J 1972;9:194–209.

Larson O, Ideberg M, Nordin KE. Early bone grafting in complete cleft lip and palate cases following maxillofacial orthopedics. III. A study of the dental occlusion. Scand J Plast Reconstr Surg 1983;17:81–92.

Manchester WM. The repair of double cleft lip as part of integrated program. Plast Reconstr Surg 1970;45:207–216.

Moorrees CFA. The dentition of the growing child: a longitudinal study of dental development between 3 and 18 years of age. Cambridge, MA: Harvard University Press, 1959.

Ross RB, Johnston MC. Cleft lip and palate. Baltimore: Williams & Wilkins, 1972.

Rune B, Sarnäs KV, Selvik G, Jacobsson S. Movement of maxillary segments after expansion and/or secondary bone grafting in cleft lip and palate: a röntgen stereophotogrammetric study with the aid of metallic implants. Am J Orthod 1980;77:643–653.

Van der Linden FPGM, Boersma H, Zelders T, Peters KA, Raaben JH. Three dimensional analysis of dental casts by means of the Optocom. J Dent Res 1972;51:1100.

Vargervik K. Growth characteristics of the premaxilla and orthodontic treatment principles in bilateral cleft lip and palate. Cleft Palate J 1983;20:289–302.