Longitudinal changes in the skeletal pattern of deciduous anterior crossbite

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A crossbite in the deciduous dentition often precedes a crossbite in the permanent dentition. Saito[1] reported on the spontaneous correction of deciduous crossbite. Leighton[2] and Nezu[3] presented case reports that showed spontaneous correction of the deciduous anterior crossbite. Yamasaki et al.[4] observed occlusal changes in students with crossbite from 11 years to 16 years.

We evaluated longitudinal changes in subjects with deciduous crossbite[5-7] and found that self-correction occurred in some subjects after the eruption of the permanent dentition, but the crossbite persisted in others. Self-correction occurred either during the deciduous dentition period or during the transitional stage leading to the permanent dentition. In the group showing self-correction (group N), the following characteristics were observed at the initial visit: normal skeletal pattern with labially tipped mandibular deciduous incisors and anterior functional shift from centric relation to centric occlusion; crossbite within $\frac{52,51 \mid 61,62}{83,82,81 \mid 71,72,73}$; negative overjet and overbite smaller than in the group showing persistence of crossbite (group R); no contact between maxillary and mandibular deciduous canines in centric occlusion, with

Abstract

Some patients who have an anterior crossbite in the deciduous dentition lose the crossbite during the transitional stage to permanent anterior teeth without orthodontic and/or orthopedic treatment. We observed 220 anterior crossbite patients at regular intervals and identified three groups of patients: in group N (n=16) the crossbite corrected when the central incisors erupted; in group R_1 (n=16) the crossbite was within $\frac{52,51 \mid 61,62}{83,82,81 \mid 71,72,73}$ and remained unchanged following the eruption of the permanent central incisors; in group R_2 (n=12) the crossbite extended over $\frac{52,51 \mid 61,62}{83,82,81 \mid 71,72,73}$ and remained following the eruption of the permanent central incisors. The purpose of this study was to determine whether any differences existed among the above three groups at the initial examination, or if differences arose during eruption of the teeth. The findings indicate that the mandibular position in group N was more posterior than in groups R_1 and R_2, and the lengths of Pog'-Go and Gn-Cd in group N were smaller. Tooth axis of the lower incisors in groups R_1 and R_2 showed lingual tipping, and the maxilla in group R_2 was underdeveloped. The findings of the longitudinal changes indicated that the maxillary length in group N increased and mandibular forward growth was suppressed. The initial maxillary position in groups R_1 and R_2 remained much the same until the permanent central incisors erupted.

Key Words

Deciduous anterior crossbite • Longitudinal study • Cephalometry

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Table 1
Ages (months) from stage A to stage E between groups N, R_1, and R_2

Group	Stage A Mean ± SD (mo)	Stage B Mean ± SD (mo)	Stage C Mean ± SD (mo)	Stage D Mean ± SD (mo)	Stage E Mean ± SD (mo)
N (n=16)	43.1 ± 5.5	54.8 ± 4.7	65.9 ± 4.2	78.8 ± 4.6	91.6 ± 4.4
R_1 (n=16)	43.8 ± 6.5	54.5 ± 6.4	66.5 ± 5.7	78.6 ± 5.4	89.8 ± 5.6
R_2 (n=12)	45.6 ± 7.9	56.5 ± 8.4	68.9 ± 8.7	81.0 ± 7.1	92.8 ± 8.2

occlusal conditions that limited mandibular movement; positive overjet or edge-to-edge occlusion in construction bite (the most retrusive mandibular position). In addition, immediately before the crossbite improved, the subjects showed a decrease in overbite due to occlusal wear of the maxillary deciduous incisors and eruption of the maxillary second deciduous molars. This decreased cuspal interference of the anterior teeth and easy retrusion of the mandible, which was placed functionally in the anterior position, resulted in improvement of the crossbite.

In the present study, we observed crossbite subjects as they moved from the deciduous dentition to the eruption of the permanent incisors, evaluated the characteristics of crossbite at the early stage of the deciduous dentition period, and observed the ongoing morphological changes that occurred with eruption of the permanent incisors.

Materials and methods

Subjects

Of 220 patients with deciduous crossbite who were observed at regular intervals at our department, 44 females who fulfilled the following criteria were evaluated: absence of marked midline shift; normal morphology and number of teeth; no history of previous crown restoration or treatment that would have induced changes in occlusion. Lateral cephalometric radiographs were analyzed. The subjects did not receive any active orthodontic treatment, including the hand pressure correction method or the inclined plane method, during the observation period.

The subjects were divided into the following three groups.

Group N: The crossbite in the deciduous dentition was within $\frac{52,51 \mid 61,62}{83,82,81 \mid 71,72,73}$. With eruption of the permanent central incisors, normal overbite was observed in $\frac{11 \mid 21}{42,41 \mid 31,32}$ (n=16).

Group R_1: The crossbite in the deciduous dentition was the same as in group N, and it persisted following eruption of the permanent central incisors (n=16).

Group R_2: The crossbite in the deciduous dentition was beyond $\frac{52,51 \mid 61,62}{83,82,81 \mid 71,72,73}$, and it persisted following eruption of the permanent central incisors (n=12).

A functional shift to the edge-to-edge incisor position was possible in all subjects in group N, but impossible in 1 subject in group R_1 and 6 in group R_2.

Occlusal growth from the deciduous to the permanent dentition was classified into five stages (A to E). The mandibular permanent central incisors overlapped the maxillary deciduous incisors at stage D. Stages C, B, and A were defined as 1, 2, and 3 years, respectively, before stage D. Stage E occurred 1 year after stage D (Table 1).

Methods

Lateral cephalometric radiographs were analyzed using Iizuka's method.[8] The 11 angular measurements used are shown in Figure 1 and the 17 linear measurements used are shown in Figure 2. (UA and LA stand for upper and lower deciduous incisors, respectively. S', ptm', and A' are perpendicular to FH plane from S, ptm and A; ms', is' and ii' are perpendicular to occlusal plane from midpoint on the occlusal surface of the upper first molar, edge of the upper incisor, and edge of the lower incisor.) Means and standard deviations were calculated.

Lateral cephalometric radiographs were traced by one person and checked by another. Angular and linear data were recorded by one investigator using a digitizer (Logitec MYPAD-A3), processed with a microcomputer (Fujitsu FM R60), printed (Fujitsu MB27410ADO4B-5470-B180), and represented by an xy-plotter (Watanabe WX4675). Five cephalograms were randomly selected for one investigator to trace and enter six times. Standard deviation (SD) of measurement error was calculated using Baumrind's method[16] to evaluate measurement error. The SD value times four was used as the measurement error range.

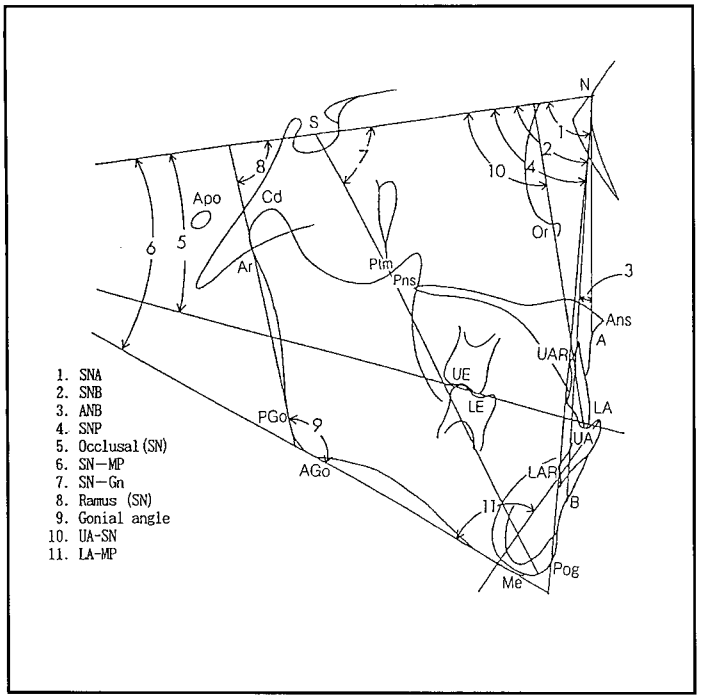

Figure 1

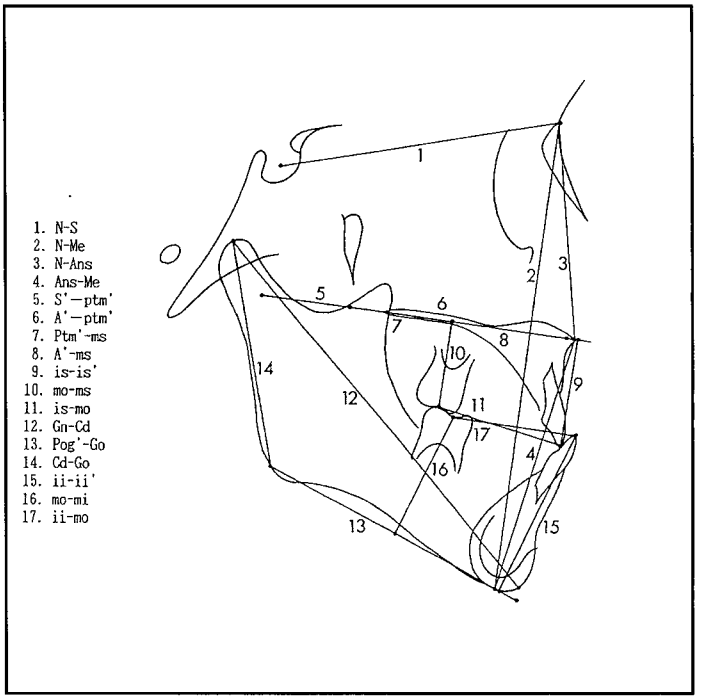

Figure 2

The mean and SD for each measurement were calculated. One-way ANOVA was used to determine significant differences among individual groups. When ANOVA was significant, Scheffe's multiple comparison test was used to test between-group differences.

Results

Comparison among groups N, R_1, and R_2 at stage A

The results of angular measurement are shown in Table 2 and Figure 3. Among the items representing the anteroposterior positional relationship between the maxilla and the mandible, SNA was similar in all 3 groups and SNB was smaller in group N than in the other groups. ANB was significantly larger in group N than in R_2.

Among the items showing the dental axis, LA-MP was significantly smaller in group R_2 than in group N.

The results of linear measurement are shown in Table 3 and Figure 3. The maxillary anteroposterior size (A'-Ptm') was significantly greater in group R_1 than in group R_2. In the mandible, Gn-Cd was significantly smaller in group N than in group R_1, and Pog'-Go was smaller in group N than in groups R_1 or R_2.

Longitudinal changes

Longitudinal changes in the angular measurement items are shown in Table 2 and Figure 4.

SNA showed no longitudinal changes in any group. SNB decreased in group N. SNB increased between stages A and C in all 3 groups, but decreased thereafter in group R_1 and remained constant in group R_2. ANB increased in group N. ANB decreased between stages A and C and increased thereafter in group R_1 and remained constant in group R_2.

SN-MP increased in group N but showed no changes in groups R_1 and R_2. SN-Gn increased in groups N and R_2; the increase in group N was especially marked.

Longitudinal changes in the linear measurement items are shown in Table 3 and Figure 4. Changes in N-S were similar among the 3 groups. A'-ptm' increased most markedly in group N, followed in order by R_1 and R_2. In the mandible, no differences were observed in the amount of growth of Gn-Cd or Pog'-Go among the 3 groups. Of the dental variables, upper arch length (is-mo) decreased in groups R_1 and R_2, and lower arch length (ii-mo) decreased in all 3 groups.

Discussion

Evaluation of growth according to tooth eruption age and its importance

Various factors are involved in the growth and development of the tooth. Since evaluation of the dental development according to chronological age leads to marked variations, physiological age is generally used. Among the parameters of dental calcification stages proposed by Moorrees et al.,[9] Nagahara et al.[7] suggested that the degree of root maturation is appropriate for use as a parameter during the short period of the decidu-

Figure 1
Angular measurements

Figure 2
Linear measurements

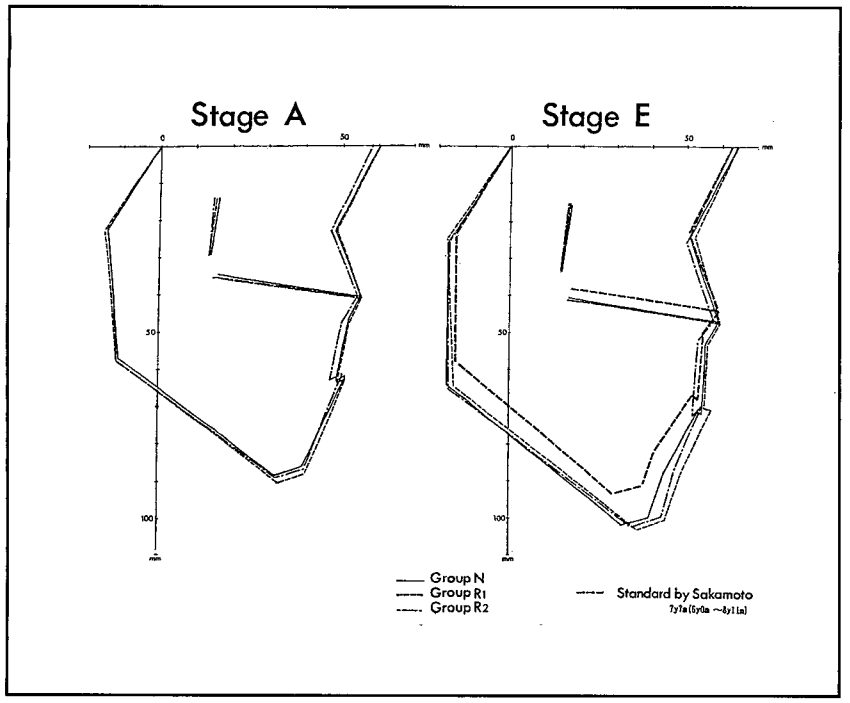

Figure 3

Figure 3
Differences of mean composed profilograms between groups N, R_1, and R_2 at stages A and E (superimposed on sella and nasion).

ous dentition.

However, during the transition period from deciduous to mixed dentition, pronounced changes occur in the occlusion due to changes in the overbite caused by eruption of the anterior teeth. These changes affect the growth and development of the maxilla and the mandible. Therefore, the time of eruption of the mandibular permanent central incisors, rather than the calcification age, seems to be the most appropriate factor for evaluating dental growth before and after the eruption. In this study, occlusal growth from the deciduous to the permanent dentition was classified into 5 stages (A to E). The stage at which the mandibular permanent central incisors and maxillary deciduous incisors overlap was called stage D. Stages C, B, and A were defined to take place 1, 2, and 3 years, respectively, before stage D, with stage E occurring 1 year after. Using this classification, transitional change from the deciduous to the permanent dentition could be brought into focus.

Table 2
Longitudinal changes of angular measurements in groups N, R_1, and R_2

Variable	Stage A Mean ± SD	B Mean ± SD	C Mean ± SD	D Mean ± SD	E Mean ± SD
Group N (n=16)					
SNA	80.1 ± 2.2	80.1 ± 2.3	80.4 ± 2.1	80.5 ± 2.1	80.1 ± 2.2
SNB	78.4 ± 2.2	77.8 ± 2.1**	78.0 ± 1.9**	77.1 ± 1.8**	76.6 ± 2.1**
ANB	1.7 ± 1.4	2.3 ± 1.6	2.4 ± 1.5	3.4 ± 1.6	3.4 ± 1.4*
SN–MP	35.1 ± 3.2	35.4 ± 3.1	35.9 ± 2.7	36.4 ± 2.5	36.4 ± 2.8
SN–Gn	68.2 ± 2.3	69.3 ± 2.7	69.9 ± 2.6	70.8 ± 2.5	71.1 ± 3.0*
UA–SN	87.2 ± 5.9	91.1 ± 7.5	91.5 ± 6.4	94.3 ± 7.0	
LA–MP	88.8 ± 4.9	85.9 ± 6.3	84.8 ± 7.5		
Group R_1 (n=16)					
SNA	81.6 ± 2.8	82.2 ± 2.5	82.0 ± 2.8	81.8 ± 2.7	81.7 ± 3.1
SNB	80.1 ± 1.8	80.8 ± 2.0	81.0 ± 2.2	79.9 ± 1.9	79.9 ± 2.5
ANB	1.5 ± 1.5	1.4 ± 1.7†	1.0 ± 1.5†	1.9 ± 1.6	1.8 ± 1.4†
SN–MP	35.7 ± 3.2	35.1 ± 3.2	36.3 ± 3.2	35.9 ± 3.1	35.8 ± 3.1
SN–Gn	68.1 ± 1.7	67.9 ± 1.7	68.8 ± 1.5	69.2 ± 1.8	68.8 ± 2.1
UA–SN	87.3 ± 3.4	87.5 ± 3.4	88.1 ± 4.3	91.6 ± 6.2	
LA–MP	83.9 ± 7.1	83.0 ± 7.6	81.9 ± 6.6		
Group R_2 (n=12)					
SNA	80.4 ± 3.5	80.8 ± 3.2	80.4 ± 3.1	80.4 ± 3.4	80.3 ± 3.8
SNB	80.4 ± 3.0	81.0 ± 2.9‡‡	80.9 ± 2.7‡‡	80.1 ± 2.6‡‡	80.1 ± 2.8‡‡
ANB	0.0 ± 1.8‡	-0.2 ± 1.6‡‡‡	-0.4 ± 1.5‡‡‡	0.4 ± 2.0‡‡‡	0.2 ± 1.9‡‡‡
SN–MP	34.7 ± 3.2	34.5 ± 3.8	34.2 ± 4.0	35.1 ± 4.0	34.7 ± 4.0
SN–Gn	67.3 ± 2.6	67.5 ± 2.7	68.0 ± 2.6	68.7 ± 2.4	68.8 ± 2.1
UA–SN	88.1 ± 6.6	88.8 ± 6.1	89.4 ± 8.5	90.6 ± 9.7	
LA–MP	83.0 ± 4.6†	80.6 ± 4.8	81.0 ± 4.7		

Significance
N vs. R_1: *$p<0.05$; **$p<0.01$
R_1 vs. R_2: †$p<0.05$
N vs. R_2: ‡$p<0.05$; ‡‡$p<0.01$; ‡‡‡$p<0.001$

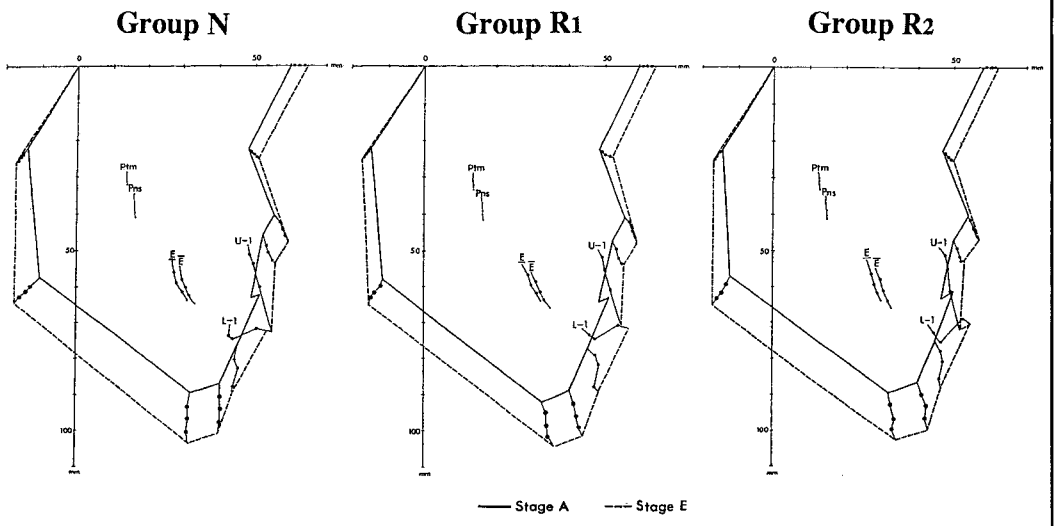

Figure 4
Longitudinal superimposition of mean changes in groups N, R_1, and R_2 indicated with dots in stages B, C, and D. Superimposed on N-S with registration at sella.

Figure 4

Table 3
Longitudinal changes of linear measurements in groups N, R_1, and R_2

Stage / Variable	A Mean ± SD	B Mean ± SD	C Mean ± SD	D Mean ± SD	E Mean ± SD
Group N (n=16)					
N–S	60.2 ± 2.1	61.6 ± 2.9	62.4 ± 2.3	63.7 ± 2.3	64.7 ± 2.3
A'–ptm'	40.4 ± 1.8	41.9 ± 1.9	42.8 ± 1.9	44.1 ± 2.1	44.9 ± 2.1
is–mo	24.3 ± 1.6	25.0 ± 2.2	24.8 ± 1.9	24.5 ± 2.0	
Gn–Cd	86.6 ± 2.8**	90.7 ± 2.5*	93.0 ± 3.2*	96.1 ± 3.5**	98.3 ± 3.2*
Pog'–Go	58.5 ± 2.2	61.4 ± 2.5	63.5 ± 2.8	66.3 ± 2.9	68.1 ± 2.9
Cd–Go	41.3 ± 2.0	43.5 ± 1.8	44.4 ± 2.4	45.8 ± 2.5	47.0 ± 2.2
ii–mo	23.2 ± 1.4	22.4 ± 1.5	21.8 ± 1.7		
Group R_1 (n=16)					
N–S	60.1 ± 1.9	60.9 ± 2.2	62.1 ± 2.2	63.4 ± 2.1	64.5 ± 2.1
A'–ptm'	41.3 ± 1.7†	42.3 ± 1.8†	43.1 ± 1.9	44.1 ± 1.9†	44.6 ± 2.0†
is–mo	24.1 ± 1.4	23.5 ± 1.2	23.2 ± 1.6	23.5 ± 1.7	
Gn–Cd	90.4 ± 3.2	93.6 ± 3.1	97.2 ± 4.0	100.4 ± 3.3	103.0 ± 3.6
Pog'–Go	60.6 ± 2.6	63.0 ± 3.1	65.8 ± 3.6	68.3 ± 3.4	70.0 ± 3.3
Cd–Go	42.6 ± 2.2	44.4 ± 2.0	45.8 ± 2.4	47.4 ± 2.2	48.7 ± 2.3
ii–mo	23.2 ± 1.6	22.8 ± 1.6	22.5 ± 1.8		
Group R_2 (n=12)					
N–S	58.4 ± 2.5	59.3 ± 2.3‡	60.7 ± 2.9	61.7 ± 2.9	62.4 ± 3.3
A'–ptm'	39.5 ± 1.8	40.1 ± 2.0	41.1 ± 2.1	42.1 ± 2.1‡	42.2 ± 1.9‡‡
is–mo	23.7 ± 2.0	22.9 ± 1.9‡	22.9 ± 1.9‡	23.0 ± 1.9	
Gn–Cd	87.9 ± 3.7	91.4 ± 3.7	94.8 ± 4.8	97.7 ± 4.6	101.1 ± 4.9
Pog'–Go	60.6 ± 3.0	63.2 ± 2.7	65.8 ± 2.5	67.7 ± 2.6	69.9 ± 2.8
Cd–Go	41.2 ± 3.2	42.8 ± 3.2	45.1 ± 3.2	46.5 ± 2.9	48.4 ± 3.1
ii–mo	22.8 ± 1.8	22.4 ± 1.8	22.1 ± 1.4		

Significance
N vs. R_1: *$p<0.05$; **$p<0.01$
R_1 vs. R_2: †$p<0.05$
N vs. R_2: ‡$p<0.05$; ‡‡$p<0.01$;

Figure 5
Longitudinal changes in the maxilla. Mean and standard deviation in groups N, R_1, and R_2

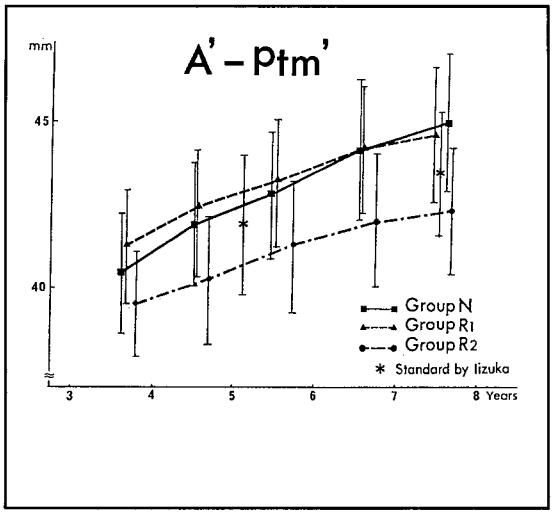

Figure 5

Characteristics at stage A

Sasaki [10] reported that the maxillary base is significantly smaller in patients with deciduous crossbite when ANB ≤ 0 compared with subjects who have normal occlusion.

In the present study, SNA—representing maxillary position—was greatest in group R_1, but the differences among the 3 groups was not significant. Anterior cranial base (N-S) was smallest in group R_2. Therefore, the maxilla was positioned more posteriorly in group R_2 when the profilograms in the 3 groups were superimposed on S-SN (Figure. 3). The maxilla was definitely smaller in group R_2 than in group R_1.

On the other hand, the mandible was clearly positioned more posteriorly in group N than in the other two groups. Mandibular length (Gn-Cd) was smaller in group N than in group R_1, and the mandibular body length (Pog'-Go) was also smaller.

Thus, at stage A, group N already showed a better mandibular position than the other two groups, resulting in a larger ANB angle. ANB did not differ between groups N and R_1, the groups with relatively small crossbite. However, group R_2, with more extensive crossbite, showed a markedly smaller ANB angle, suggesting the skeletal abnormalities were greater.

Susami[11] reported that the axis of the mandibular central incisors in patients with crossbite becomes small from stage IC to IIIA. Similar findings were also reported by Hosoki et al.[12] in 6-year-old children with posteriorly positioned maxillas and anteriorly positioned mandibles.

In our previous studies,[5-7] overbite was found to be a useful indicator of cases that might self-correct during the deciduous dentition period. Even when occlusal wear occurs in crossbite patients showing marked positive overbite, self-correction during the deciduous dentition period does not occur.

In the present study, the mandibular central incisors were lingually inclined in groups R_1 and R_2 compared with group N. This finding suggests that the mechanism for dental compensation was already present at stage A.

Longitudinal changes

Yamasaki et al.[4] observed primary school students with crossbite longitudinally for 5 years. He reported that the mandible did not show acute overgrowth and that the occlusal characteristics present at the early stage persisted later. Sawa[10] evaluated dental growth and development in patients with crossbite in Hellman's dental stages IIC to IIIB and reported that the anterior cranial base and maxilla tended to be small at 6 to 7 years, and subsequently grew less than normal. He also found that mandibular length and mandibular body length were already great at stage IIC in females, and that subsequent growth until the acute increasing stage during puberty was similar to that of normal occlusion. The same investigator also observed that the anteroposterior relationship between the mandible and maxilla became worse with growth.

Occlusal characteristics found at the initial observation persisted in both the maxilla and the mandible during growth in groups R_1 and R_2 (Figures 5 and 6). This may be because the crossbite in the deciduous dentition persisted until the permanent incisors had erupted. On the other hand, group N showed additional growth of the maxilla, and self-correction was observed during the deciduous dentition period in 13 of 16 subjects. This improvement in crossbite, which impairs anterior maxillary growth, affected subsequent growth (Figure 5).

Mandibular length (Gn-Cd) at age 5 was already great in all three groups compared with the mean values of Iizuka,[8] as shown in Figure 6. Although subsequent growth was similar among all three groups, the mean value decreased in group N compared with groups R_1 and R_2. At age 7, the mean value in group N was similar to the normal occlusion of Iizuka[8] (Figure 6). As Sawa[13] also reported, anterior cranial base and the maxilla tended to be short in group R_2 even at age 6 to 7, and slight undergrowth was subsequently observed.

In group N, which showed normal overbite at stage E, the mandible was still anteriorly positioned compared with the standard value of Sakamoto[14] (Figure 3). Despite self-correction, skeletal abnormalities remained. Therefore, continuous observation may be needed.

Concerning dental changes in the deciduous dentition in patients with deciduous crossbite, Nagahara[5] reported a significant increase in the maxillary dental arch length but significant decreases in the mandible of patients who self-corrected. On the other hand, Kanematsu[15] reported slight decreases in maxillary and mandibular dental arch length in patients in whom the crossbite persisted.

In the present study, the findings from groups R_1 and R_2 were similar to those of Kanematsu.[15] However, in group N, no increase in maxillary dental arch length was observed during the deciduous dentition period. This difference may be because group N included patients who showed self-correction during the deciduous dentition period and those who continued to show crossbite.

The inclination of the mandibular deciduous central incisors at stage C did not differ significantly from the standard value at stage IIA (Iizuka[8]). However, significant lingual inclination was observed in groups R_1 and R_2. In these two groups, mandibular growth may have resulted in the anterior position of the mandible, and the mandibular deciduous central incisors may have been pushed back by the lip.

We observed changes in the maxillary and mandibular central incisor edges (U-1, L-1), which are thought to play an important role in improving crossbite (Figure 4). With maxillary growth, the maxillary permanent central incisors grew anteroinferiorly in all 3 groups. The mandibular permanent central incisors also showed changes associated with mandibular growth. In group N, since the mandible grew inferiorly between stages A and C, the position of the permanent incisors also showed inferior and slight anterior changes. Since anteroinferior mandibular growth was marked, the mandibular permanent central incisors erupted more anteriorly in groups R_1 and R_2 than in group N, resulting in retention of the crossbite.

Regarding vertical growth, there were no significant differences in mandibular plane angle among the three groups, but lower facial height increased more in group N than in group R_2. Moreover, because overbite in group N was smaller than in group R_2, more vertical growth tendency may be observed to achieve spontaneous correction of crossbite.

Between stages C and D, the mandibular permanent central incisors in all 3 groups showed anterosuperior changes as they began to erupt. Thus, the eruption pathways of the permanent incisors varied greatly in terms of the growth of the maxilla and mandible.

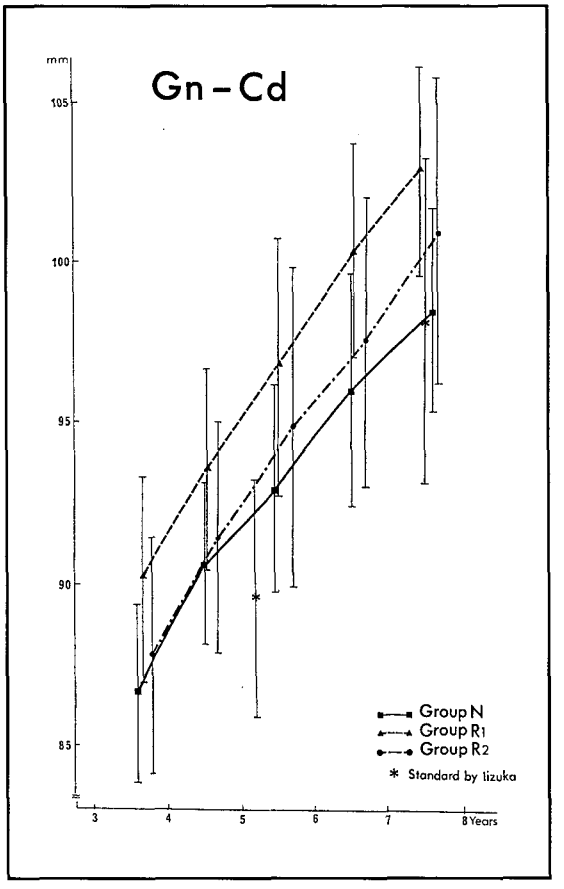

Figure 6
Longitudinal changes in the mandible. Mean and standard deviations in groups N, R_1, and R_2

Figure 6

Conclusions

The present findings, in conjunction with our previous reports, support the following conclusions:

1. The mandibular position in group N was more backward than in groups R_1 and R_2, and the lengths of Pog'-Go and Gn-Cd were smaller.
2. Tooth axis of the lower incisors in groups R_1 and R_2 showed lingual tipping, and the maxilla in group R_2 was underdeveloped.
3. Maxillary growth increased in group N, and mandibular forward growth was suppressed. The initial maxillary position in groups R_1 and R_2 remained much the same until the permanent central incisors erupted.

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