

Anterior open bite in the deciduous dentition: Longitudinal follow-up and craniofacial growth considerations

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The aim of this longitudinal cephalometric study was to evaluate craniofacial growth changes in subjects with an anterior open bite in the deciduous dentition. From longitudinal records of untreated subjects, an open bite group ($n = 14$) was selected at the age of 5 years based on the presence of a negative overbite and compared with a control group ($n = 14$) with a regular overbite at this age. Cephalometric measurements were analyzed at ages 5, 9, and 12 years. Although only 1 subject in the deciduous dentition open bite group had an open bite at 12 years of age, the overbite remained lower during the longitudinal follow-up. Early cephalometric characteristics of the open bite group included a reduced overbite depth indicator and a lower ANB angle. At ages 9 and 12 years, the open bite sample was also characterized by shorter ramus height. An underlying skeletal pattern seems to be present in the deciduous dentition open bite sample that persists during the longitudinal follow-up. The overbite depth indicator might help to identify patients with anterior open bite tendencies. (*Am J Orthod Dentofacial Orthop* 2002;122:353-8)

There is general agreement that patients with an anterior open bite or an open bite tendency are among the most challenging to treat. Relapse of overbite correction at long-term follow-up is a common finding not only after orthodontic treatment but also after surgical orthodontic therapy.^{1,2}

A number of cephalometric characteristics have been ascribed to the patient with an anterior open bite or an open bite tendency: large anterior dentoalveolar height in both jaws, increased total and lower anterior face height, a disproportionate ratio of upper-to-lower anterior face height, decreased posterior face height and an increased gonial angle, a high mandibular plane angle, a low posterior-to-anterior face height ratio, and a short ramus. There are conflicting data regarding the size and the shape of the symphysis.³⁻⁵ Although some have advocated using these features to evaluate the feasibility of overbite correction by orthodontic treat-

ment, it has also been demonstrated that most subjects with cephalometric parameters indicating a skeletal open bite pattern show dentoalveolar compensatory changes resulting in a positive overbite.^{5,6}

In general, overbite increases during the mixed dentition period. Worms et al⁷ reported on self-correction of 80% of the anterior open bites from a 7-to-9-year-old to a 10-to-12-year-old sample. There seems to be a slight decrease in overbite from 12 to 18 years of age and some correlation between the overbite at different ages.⁸ Skeletal signs have been identified in Class I and Class II open bite subjects in the early transitional dentition.⁹ Although self-correction of the open bite has been demonstrated, there is a paucity of information about whether a certain skeletal pattern is associated with an early open bite and whether any skeletal characteristics can still be found after the open bite has corrected spontaneously.

The aim of the present study was to assess changes in overbite during the longitudinal follow-up in a sample of subjects with anterior open bites in the deciduous dentition. Furthermore, the study tried to answer which cephalometric parameters are associated with an anterior open bite at the deciduous dentition stage and during the longitudinal follow-up.

MATERIAL AND METHODS

The records were obtained from the Child Research Council in Denver, Colorado, and included longitudinal

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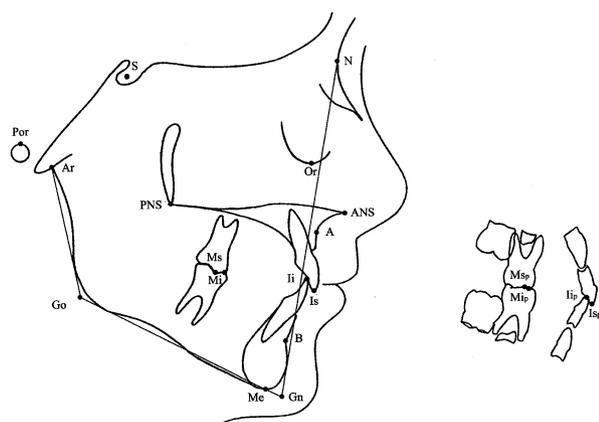


Fig. Cephalometric landmarks.

data from annual lateral cephalometric radiographs. All subjects were white and had not received orthodontic treatment. Selection of the open bite sample was based on a negative deciduous incisor overbite when measured to the occlusal plane at the age of 5 years. Fourteen subjects with negative overbites were chosen. The open bite was slight to moderate with a mean overbite of -0.7 mm (range -0.1 to -2.4 mm). A control group ($n = 14$) was chosen based on a normal overbite at this age (mean overbite, 1.9 mm; range, 1.5 to 2.3 mm). All subjects had a positive overjet both at the initial observation and at the longitudinal follow-up.

The cephalometric analysis was based on the following landmarks (Fig): incisal edge of the maxillary incisor (Is), incisal edge of the maxillary deciduous incisor (Is_p), incisal edge of the mandibular incisor (Ii), incisal edge of the mandibular deciduous incisor (Ii_p), mesial cusp tip of the maxillary permanent first molar (Ms), mesial cusp tip of the mandibular permanent first molar (Mi), mesial cusp tip of the maxillary deciduous second molar (Ms_p), mesial cusp tip of the mandibular deciduous second molar (Mi_p), Point A (A), Point B (B), sella (S), nasion (N), porion (Por), orbitale (Or), articulare (Ar), gonion intersection (Go), menton (Me), anterior nasal spine (ANS), posterior nasal spine (PNS), and gnathion (Gn). An occlusal plane (OP) was defined as the line bisecting the overlapping cusps Ms and Mi posteriorly and the incisal overbite Is-Ii anteriorly. The deciduous dentition occlusal plane (OP_p) was constructed bisecting Ms_p - Mi_p posteriorly and Is_p and Ii_p anteriorly. All cephalometric landmarks were traced with a cross-wires cursor to digitize landmarks with the Dentofacial Planner system (Dentofacial, Toronto, Ontario, Canada).

Linear measurements to assess incisor relationship: overbite (distance Is_p - Ii_p measured parallel to OP_p at age 5 years, distance Is-Ii measured parallel to OP at ages 9 and 12 years).

Linear measurements to assess vertical growth: ANS-Me, N-Me, and Ar-Go.

Angular measurements to assess the sagittal growth pattern: SNA, SNB, and ANB.

Angular measurements to assess vertical growth: S-N MP (sella nasion line to mandibular plane Go-Me); S-N PP (sella nasion line to palatal plane ANS-PNS); PP MP (palatal plane ANS-PNS to mandibular plane Go-Me); N-S-Gn (y-axis); and overbite depth indicator (ODI) according to Kim¹⁰: combined measurement calculated as the sum of the angle between a line from Point A to Point B and mandibular plane Go-Me, and the angle between palatal plane ANS-PNS and Frankfort horizontal plane Por-Or.

Angular measurements to assess mandibular morphology: Ar-Go-Me (gonial angle), Ar-Go-N (upper gonial angle), and N-Go-Me (lower gonial angle).

Dahlberg's formula¹¹ was used to calculate the method error on 25 randomly selected radiographs. The method error was found to be 0.49° for the angular measurements and 0.45 mm for the linear measurements.

For the overbite and each cephalometric variable and each group median, means and standard deviations were calculated at ages 5, 9, and 12 years. The data of the 2 groups at the different ages were compared by a Mann-Whitney *U* test for independent samples ($P < .05$).

RESULTS

The overbite measurements of the deciduous dentition open bite group and the control group are given in Table I. Of the 14 subjects with open bites at 5 years of age, 3 had negative overbites at 9 years, and, at age 12, only 1 still had an open bite. The comparison of the 2 groups at ages 5, 9, and 12 years showed significant differences in overbite at all ages. The overbite in the deciduous dentition open bite group increased with age but remained lower than in the control group.

Descriptive data of the cephalometric analysis and the results of the Mann-Whitney test for the deciduous dentition open bite group and the control group at age 5 are shown in Table II. Significant differences for the 2 groups were found for ODI and ANB. For the open bite group, the mean ODI measurement of 68.7° was significantly lower ($P < .01$) than the average ODI measurement of the control group of 74.5° . The open bite group was also characterized by a significantly lower ($P < .05$) ANB value (mean 3.3°) when com-

Table I. Descriptive statistics and statistical comparison of overbite

Age (y)	Deciduous dentition open bite group (n = 14)					Control group (n = 14)					Mann-Whitney test	
	Median	Mean	SD	Min	Max	Median	Mean	SD	Min	Max	Z	P
5	-0.6	-0.7	0.6	-2.4	-0.1	1.9	1.9	0.3	1.5	2.3	-4.510	.000***
9	1.7	1.6	2.1	-1.3	5.5	4.3	4.1	1.4	1.3	6.3	-3.081	.001**
12	3.0	2.7	1.6	-1.0	5.1	4.5	4.7	1.0	3.2	6.3	-3.381	.000***

** $P < .01$, *** $P < .001$.

SD, Standard deviation; Min, minimum; Max, maximum.

Table II. Descriptive statistics and statistical comparison of groups at age 5 years

Cephalometric measurements	Deciduous dentition open bite group (n = 14)			Control group (n = 14)			Mann-Whitney test	
	Median	Mean	SD	Median	Mean	SD	Z	P
S-N MP (°)	35.2	34.3	5.0	31.8	32.2	2.6	-1.379	.178
S-N PP (°)	5.9	5.4	3.2	5.6	5.7	2.8	0.000	1.000
PP MP (°)	30.2	28.8	4.6	26.4	26.5	3.4	-1.471	.150
Y-axis (°)	66.3	66.3	3.9	65.3	65.2	2.5	-1.080	.285
Ar-Go-Me (°)	131.0	129.2	6.8	126.9	127.3	5.1	-0.873	.401
Ar-Go-N (°)	55.2	56.2	4.3	57.8	56.3	4.4	-0.092	.946
N-Go-Me (°)	73.4	73.1	3.4	70.7	71.0	2.3	-1.586	.114
ODI (°)	67.4	68.7	5.2	76.5	74.5	4.8	-2.826	.004**
S-N-A (°)	80.8	81.2	3.8	82.5	82.1	2.7	-0.643	.541
S-N-B (°)	76.4	77.9	4.0	78.2	77.6	2.3	-0.690	.511
A-N-B (°)	2.7	3.3	2.0	4.8	4.5	1.5	-2.437	.014*
S-Go/N-Me (%)	63.2	63.6	4.5	64.3	64.9	2.2	-0.965	.352
ANS-Me/N-Me (%)	58.6	59.1	2.3	59.3	59.2	1.7	-0.115	.910
S-Ar (mm)	26.4	26.4	2.6	26.5	26.9	2.0	-0.299	.769
Ar-Go (mm)	35.1	35.6	3.1	36.3	36.3	2.1	-1.058	.306
ANS-Me (mm)	54.7	54.8	3.7	55.0	54.9	3.1	-0.115	.910
N-Me (mm)	92.6	92.7	3.7	92.7	92.7	3.5	-0.069	.946

* $P < .05$; ** $P < .01$.

SD, standard deviation.

pared with the control group (mean 4.5°). In the open bite group, there was a trend to higher recordings for the mandibular plane angle (S-N MP), palatal plane angle (S-N PP), and lower gonial angle (N-Go-Me). However, these differences were not found to be statistically significant.

Descriptive data of the cephalometric analysis and the results of the Mann-Whitney test for the open bite group and the control group at age 9 years are shown in Table III. In addition to the significant differences in ODI and ANB measurements that were already present at age 5, the open bite group was also characterized by significantly shorter ramus length Ar-Go (mean 38.7 mm, $P < .05$) when compared with the control group, with a mean ramus length of 41.0 mm.

Descriptive data of the cephalometric analysis and the results of the Mann-Whitney test for the deciduous dentition open bite group and the control group at age 12 are shown in Table IV. Both the mandibular plane

angle (S-N MP) and the palatal plane angle (S-N PP) showed higher mean values for the open bite group, whereas only the difference in palatal plane angle was statistically significant ($P < .05$). There were significantly lower ANB and ODI measurements in the open bite group ($P < .05$ and $P < .01$, respectively). Furthermore, ramus length was on average 3.4 mm shorter in the open bite group ($P < .01$).

DISCUSSION

The deciduous dentition open bite sample in the present study was characterized by a slight-to-moderate negative overbite. Although no habits had been noted, because of the young ages of the subjects, digit sucking or other habits cannot be ruled out. Longitudinal studies on dental casts for overbite change during the deciduous dentition have been conducted by Moorrees¹² and Eismann and Reichert.¹³ Both studies showed that the amount of overbite in the permanent dentition is not

Table III. Descriptive statistics and statistical comparison of groups at age 9 years

Cephalometric measurements	Deciduous dentition open bite group (n = 14)			Control group (n = 14)			Mann-Whitney test	
	Median	Mean	SD	Median	Mean	SD	Z	P
S-N MP (°)	35.3	33.5	5.1	31.6	31.7	3.3	-1.287	.210
S-N PP (°)	6.2	5.8	3.9	7.0	6.9	3.1	-0.575	.571
PP MP (°)	27.3	27.7	4.4	25.4	24.8	3.5	-1.654	.104
Y-axis (°)	67.3	66.4	3.8	66.8	66.2	2.5	-0.483	.635
Ar-Go-Me (°)	127.2	126.5	5.3	122.7	123.1	5.0	-1.516	.137
Ar-Go-N (°)	53.5	54.0	3.8	53.0	52.6	3.7	-0.828	.427
N-Go-Me (°)	73.0	72.5	2.8	70.7	70.5	3.0	-1.678	.094
ODI (°)	65.4	67.3	4.9	73.8	73.6	4.0	-2.895	.003**
S-N-A (°)	79.6	80.1	4.2	81.7	81.5	2.8	-1.057	.306
S-N-B (°)	76.1	78.1	4.3	78.1	77.7	2.1	-0.184	.874
A-N-B (°)	1.2	2.0	1.9	4.2	3.7	1.5	-2.853	.004**
S-Go/N-Me (%)	63.1	64.2	4.6	65.6	65.7	2.7	-1.264	.210
ANS-Me/N-Me (%)	56.8	57.4	1.9	56.8	57.2	2.2	-0.207	.839
S-Ar (mm)	30.3	30.0	2.7	30.4	30.4	2.4	0.138	1.910
Ar-Go (mm)	37.8	38.7	2.9	40.7	41.0	2.0	-2.229	.024*
ANS-Me (mm)	58.6	58.6	3.9	59.2	59.3	3.3	-0.322	.769
N-Me (mm)	103.2	102.4	5.1	104.3	103.8	3.4	-0.759	.454

* $P < .05$; ** $P < .01$.

SD, standard deviation.

Table IV. Descriptive statistics and statistical comparison of groups at age 12 years

Cephalometric measurements	Deciduous dentition open bite group (n = 14)			Control group (n = 14)			Mann-Whitney test	
	Median	Mean	SD	Median	Mean	SD	Z	P
S-N MP (°)	35.1	33.2	5.1	31.1	30.5	3.1	-1.700	0.094
S-N PP (°)	5.6	6.0	4.0	7.7	7.1	2.8	-0.919	0.376
PP MP (°)	27.6	27.2	4.4	24.2	23.4	3.3	-2.114	0.035*
Y-axis (°)	67.3	66.6	3.6	66.6	65.9	2.8	-0.644	0.541
Ar-Go-Me (°)	127.1	125.7	5.8	120.1	121.4	5.4	-1.930	0.056
Ar-Go-N (°)	53.0	53.0	3.9	50.5	51.2	4.1	-1.241	0.227
N-Go-Me (°)	73.4	72.7	3.1	70.5	70.3	3.1	-2.045	0.039
ODI (°)	67.1	67.8	5.1	74.6	73.7	4.5	-2.711	0.006**
S-N-A (°)	80.9	80.8	4.0	83.5	82.3	3.3	-0.988	0.329
S-N-B (°)	77.8	78.7	4.1	79.3	78.9	2.4	-0.506	0.635
A-N-B (°)	2.2	2.1	1.8	3.5	3.4	1.8	-2.298	0.021*
S-Go/N-Me (%)	62.9	64.8	4.5	66.3	67.0	2.5	-1.792	0.077
ANS-Me/N-Me (%)	56.0	56.9	2.0	56.2	56.4	2.2	-0.552	0.603
S-Ar (mm)	32.8	32.3	2.7	32.2	32.2	2.6	-0.368	0.734
Ar-Go (mm)	40.8	41.4	2.7	44.6	44.8	2.5	-2.895	0.003**
ANS-Me (mm)	61.4	61.7	4.7	61.4	61.8	3.5	-0.092	0.946
N-Me (mm)	109.1	108.3	6.0	109.6	109.6	4.0	-0.621	0.541

* $P < .05$; ** $P < .01$.

SD, standard deviation

closely related to the amount of overbite in the deciduous dentition. However, Bergersen⁸ and Bishara and Jacobsen¹⁴ showed some correlation between the overbite at different ages during the longitudinal follow-up. The present study found an increase in overbite in the open bite group, resulting in a positive overbite at 12

years of age in 13 of 14 subjects. This agrees with the findings of Worms et al,⁷ who showed that most early open bites are self-correcting. Nevertheless, the overbite was found to be significantly lower even at 12 years of age. This does indicate a consistent pattern in overbite development and is consistent with Bergersen⁸

and Bishara and Jacobsen.¹⁴ In the present sample, an underlying overbite pattern was present in the deciduous dentition open bite group that persisted even though the open bite generally self-corrected.

From a clinician's point of view, the question is whether the former open bite subjects respond differently to orthodontic treatment. Although these people no longer have actual open bites, do they have open bite tendencies? There is no generally accepted method to identify the patient with an open bite tendency. Wardlaw et al¹⁵ questioned the validity of vertical growth parameters such as a steep mandibular plane angle or a low upper/lower facial height ratio to identify patients with open bite tendencies during treatment. Dung and Smith¹⁶ pointed out that most patients who have cephalometric measurements suggesting open bites do not in fact have open bites. They stated that the problem of predicting open bite tendencies might be caused by using the wrong cephalometric variables. In the present study, the deciduous dentition open bite group was characterized by a significantly lower ODI measurement both during the initial measurement at 5 years of age and at the longitudinal follow-up. As a combination of 2 variables, the ODI might reflect both skeletal and dentoalveolar variations that cannot be evaluated by a single measurement and might be more appropriate for understanding the skeletal factors involved.^{15,17} The ODI was intended by Kim¹⁰ to provide information regarding the behavior of vertical relationships. According to Beane,¹⁸ the value of this measurement is that it purports to identify patients who have open bite tendencies; the bite-opening trend should be predicted when the ODI figure is lower. Therefore, it can be speculated that the lower ODI measurement indicates an open bite tendency; the typical patient with an anterior open bite during the deciduous dentition might be characterized by growth features that could result in bite opening during orthodontic treatment.

The correlation between ramus height and overbite was discussed early by Diamond¹⁹ and Wylie.²⁰ Diamond¹⁹ had postulated that a short ramus might be the cause for insufficient overbite, and Wylie²⁰ and, later, Richardson²¹ questioned the correlation between overbite and length of the ramus. Haralabakis et al,²² Ellis and McNamara,²³ and Ellis et al²⁴ showed that, in adult Class II and Class III open bite subjects, a short mandibular ramus is typical. The results of the present study indicate that short ramus height might be a characteristic that is not necessarily present early, but it tends to become more pronounced during the mixed dentition period.

The analysis of the cephalometric variables at the different ages demonstrated differences for both the

vertical and open bite parameters and the ANB angle mainly due to lower SNA values in the open bite group. This indicated that there might be a Class III tendency in the open bite group; it agrees with the findings of Haralabakis et al,²² who found an underdeveloped or posteriorly positioned maxilla in adult open bite subjects. Sato et al²⁵ identified a common etiology for Class III and open bite: the posterior discrepancy induces changes of the occlusal plane related to open bite and Class III development, and the abnormal growth of the mandible is due to a functional displacement of the mandible from occlusal interferences provided by a discrepancy in the molar region. However, inferences based on the ODI must be interpreted carefully. There has been criticism of the validity of the ODI in Class III patients: Miyajima et al²⁶ stated that the reason for this is that the AB-to-MP angle is smaller in Class III patients, so that most of them are diagnosed as having open bites. The authors suggested a weighted vertical indicator consisting of facial axis, mandibular plane angle, and lower anterior face height instead. Further studies need to be conducted to clarify the correlation between Class III and anterior open bite.

CONCLUSIONS

1. Thirteen of 14 subjects with an anterior open bite at age 5 years were characterized by a positive overbite when followed longitudinally until age 12. However, the overbite at 12 years was lower when compared with the control group.
2. Early cephalometric characteristics of the deciduous dentition open bite included lower measurements for the overbite depth indicator and the ANB angle. During the longitudinal follow-up, the deciduous dentition open bite sample was also characterized by shorter ramus height Ar-Go.
3. It can be assumed that there is an underlying skeletal pattern in the deciduous dentition open bite group that is present also at longitudinal follow-up. The ODI might be a sensitive measurement and help to identify the patient with an anterior open bite tendency.

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