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Longitudinal growth changes in subjects with deepbite

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Introduction: This study was a cephalometric evaluation of the growth changes in untreated subjects with deepbite at 4 time points during their developmental ages (from the early mixed dentition to the permanent dentition, and from the prepubertal phase to young adulthood). **Methods:** A sample of 29 subjects with deepbite (overbite >4.5 mm) was followed longitudinally from about 9 through about 18 years of age. Dentofacial changes at 4 times, defined by the cervical vertebral maturation method, were analyzed on lateral cephalograms. Nonparametric statistical analysis was used for comparisons. **Results:** Overbite improved on average by 1.3 mm between the first and last measurements; it worsened significantly during the prepubertal period, but it improved significantly at the pubertal growth spurt. From the prepubertal ages through young adulthood, overbite improved in 83% of the subjects and self-corrected in 62% of the subjects. Improvements in overbite were related to the initial amount of maxillary incisor proclination. The significant improvement in overbite during the adolescent growth spurt depended on the amount of vertical growth of the mandibular ramus and the eruption of the mandibular molars. **Conclusions:** Subjects with deepbite showed worsened occlusal conditions during the prepubertal and mixed dentition phases, but had significant improvements thereafter. Improvements in overbite cannot be predicted on the basis of skeletal vertical relationships. These results provide useful indications for appropriate orthodontic treatment timing for an increased overbite. (Am J Orthod Dentofacial Orthop 2011;140:202-9)

Deepbite is an occlusal condition characterized by an excessive vertical overbite. The increased depth of the bite at the incisor level can be associated with skeletal hypodivergence, otherwise called short-face syndrome or low-angle disharmony.[1] Deepbite is a frequent problem, especially in patients with Class II malocclusions.[2,3] About 50% of non-Hispanic white adolescents in the United States have an overbite greater than 4 mm, and over 10% of them have an overbite greater than 6 mm.[2] Reported unfavorable consequences of an untreated deepbite include increased anterior crowding, maxillary dental flaring, and associated periodontal sequelae.[3-6] Increased overbite has been regarded as a possible cause of severe interference with lateral and anterior mandibular movements in mastication and temporomandibular joint problems.[5,7]

Despite the high prevalence of increased overbites in the general population, few authors have analyzed changes in the depth of the bite during growth. A series of studies has described the development of "normal overbite" and its variations during the mixed and permanent dentitions,[8-14] sometimes with analysis of small subsamples of subjects showing increased overbite at different age periods.[10,13] Only Bergersen[5] attempted an extensive study on the changes in overbite from 8 to 20 years of age. He classified the sample into subjects with increased overbite (>3 mm) and normal or decreased overbite (≤3 mm). General trends observed in this study for the increased overbite group were that 80% of the overbites greater than 3 mm at 8 years still exceeded 3 mm by adulthood, and overbite increased during the exchange of incisors and deciduous molars from 8 to 11 years of age, whereas it decreased during eruption of the second and third molars between 13 and 20 years of age. The study by Bergersen,[5] however, was semilongitudinal, because the subjects were not the same at all developmental ages. Moreover, the investigation focused on changes in overbite in general and not on changes in deepbite in particular. Finally, no appraisal of individual skeletal maturity concurrent

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with the changes in overbite was performed, although this aspect is vital to longitudinal studies of growing subjects.[15-17]

Occlusal changes in postadolescent subjects with Class II Division 1 deepbite malocclusion were investigated by Feldmann et al.[3] This study was carried out on dental casts only, and it failed to find any significant worsening of the deepbites in the examined period. A 25-year follow-up study of an Icelandic population showed that, from adolescence to midadulthood, about 50% of the deepbite subjects showed improvement in overbite.[18] These epidemiologic observations were made only from clinical examinations.

The aim of our study was to provide a cephalometric evaluation of the growth changes in untreated subjects with deepbite at 4 time points during the developmental ages (early mixed dentition to permanent dentition, and prepubertal phases to young adulthood). The main features of this investigation were a specific focus on growth changes of untreated subjects with deepbite at the initial observation (overbite >4.5 mm); a longitudinal study, with the same subjects evaluated at 4 time points; and the use of a biologic indicator of individual skeletal maturity at all developmental periods.

MATERIAL AND METHODS

The files of the University of Michigan Growth Study (n = 706) and the Denver Child Growth Study (n = 155) were searched for longitudinal records of orthodontically untreated subjects with deepbite malocclusions. Lateral cephalograms of good quality at 4 consecutive developmental intervals corresponding to the different stages in cervical vertebral maturation (CS1-CS6) had to be available for all selected subjects.[19]

The first observation (T1) corresponded to CS1 (prepubertal); the second observation (T2) corresponded to CS3 (beginning of puberty); the third observation (T3) corresponded to either CS4 or CS5 (postpubertal); and the fourth observation (T4) corresponded to a developmental period that was at least 1 year after the appearance of CS6 (young adulthood). Longitudinal records for all subjects, therefore, covered the entire circumpubertal period from prepubertal through young adult stages of skeletal development. All subjects were of European-American ancestry (white) and had no craniofacial abnormalities or tooth anomalies in number or eruption (eg, supernumeraries, congenitally missing teeth, or impacted canines).

Subjects with deepbite malocclusion were diagnosed according to an overbite greater than 4.5 mm. This value agrees with an average value for the definition of increased overbite in the literature.[3,5,18,20,21] The sample consisted of 29 subjects (15 boys, 14 girls). Their mean age at T1 was 9 years 2 months ± 11 months, with all subjects in the early mixed dentition; at T2, it was 12 years 4 months ± 10 months, with subjects in the late mixed and early permanent dentitions; at T3, it was 15 years 2 months ± 11 months, with all subjects in the permanent dentition; and at T4, it was 17 years 8 months ± 11 months, with all subjects having permanent dentition. There were 13 subjects with Class I occlusion, 8 with Class II Division 1 malocclusion, and 8 with Class II Division 2 malocclusion.

Cephalograms were traced by 1 investigator (L.F.) and then verified for landmark location, anatomic contours, and tracing superimpositions by a second (T.B.). Any disagreements were resolved by retracing the landmark or structure to the satisfaction of both observers. A customized digitization regimen and analysis provided by Viewbox (version 3.1, dHAL Software, Kifissia, Greece) was used for all cephalograms examined in this study. The customized cephalometric analysis containing measurements from the analyses of Steiner,[22] Jacobson,[23] Ricketts,[24] and McNamara[25] was used, generating 29 variables—9 angular, 19 linear, and 1 ratio—for each tracing.

All sets of cephalograms were traced at the same time. Fiducial markers were placed in the maxilla and the mandible on the first tracing and then transferred to the second, third, and fourth tracings in each subject's cephalometric series, based on superimposition of internal maxillary or mandibular structures. The maxillae were superimposed along the palatal plane by registering on the bony internal details of the maxilla superior to the incisors, and the superior and inferior surfaces of the hard palate. Fiducial markers were placed in the anterior and posterior part of the maxilla along the palatal plane. This superimposition described the movement of the maxillary dentition relative to the maxilla. The mandibles were superimposed posteriorly on the outline of the mandibular canal. Anteriorly, they were superimposed on the anterior contour of the chin and the bony structures of the symphysis.[24,25] A fiducial marker was placed in the center of the symphysis and another in the body of the mandible near the gonial angle. These superimpositions facilitated measuring the movement of the mandibular dentition relative to the mandible.

The magnifications of the 2 data sets were different, with the lateral cephalograms from the University of Michigan Growth Study having a magnification of 12.1% and those from the Denver Child Growth Study having a magnification of 4%. Therefore, the lateral cephalograms from the 2 growth studies were corrected to match an 8% enlargement factor.

Before the analysis of the lateral cephalograms, the power of the study when assessing cumulative occlusal changes and skeletal changes at the 4 times, respectively, was calculated (SigmaStat version 3.5, Systat Software, Point Richmond, Calif). For the occlusal changes, on the basis of the average change in overbite (0.6 mm) and the standard deviation (1.1 mm) in untreated subjects from early adolescence to adulthood in previous studies, the power of this study with a sample of 29 subjects was 0.81 at $\alpha = 0.05$.[3,5] For the skeletal changes, on the basis of the average change in inclination of the mandibular plane to the palatal plane (3.2°) and the standard deviation (4.4°) in untreated subjects from early adolescence to adulthood in a previous study, the power of this study with a sample of 34 subjects was 0.97 at $\alpha = 0.05$.[21]

A total of 42 lateral cephalograms randomly chosen from all observations were retraced and redigitized to calculate the method error with Dahlberg's formula.[26] The errors for linear measurements ranged from 0.2 (overjet) to 0.8 mm (Pg to nasion perpendicular); the errors for angular measurements varied from 0.4° (ANB) to 1.4° (L1 to mandibular plane).

The assessment of the stages in cervical vertebral maturation on the lateral cephalograms for each subject was performed by 1 investigator (T.B.) and verified by a second (L.F.).[19] Any disagreements were resolved to the satisfaction of both observers.

Statistical analysis

Descriptive statistics for the dentoskeletal measurements in the deepbite sample at all 4 observation periods were calculated, and also for the between-stage changes (T1-T2, T2-T3, T3-T4, and the overall T1-T4). The Kolmogorov-Smirnov test showed lack of normality of distribution for several measurements used in the study. Comparisons of the values of the cephalometric variables at the 4 time periods were carried out with nonparametric statistics with the Friedman test (analysis of variance [ANOVA] on ranks for repeated measures) followed by Tukey post-hoc tests (SigmaStat software).

The prevalence rates for the following changes in overbite (variable OVB) were calculated at T2, T3, and T4 with respect to the values at T1, and they were expressed in terms of numbers of subjects showing changes during specific time intervals (T1-T2, T1-T3, and T1-T4): improvement in OVB equal to or greater than −1.5 mm (more negative change); improvement in OVB equal to or greater than −0.5 mm (more negative change); and worsening of OVB equal to or greater than +0.5 mm (more positive change).

The prevalence rates of subjects showing correction of deepbite at T2, T3, and T4 were calculated. Correction of deepbite was assessed when the OVB value was smaller than 4 mm at that time point.[27]

Logistic regression on the cephalometric variables at T1 with the value of OVB at T4 (classified as "self-corrected" when OVB was $<$4 mm vs "not corrected," when OVB was still $>$4 mm) as the dependent variable was performed (stepwise method, with P to enter $<$0.05 and P to remove $>$0.1). The aim was to identify T1 predictive variables for favorable or unfavorable outcomes in OVB.

A multiple linear regression analysis was performed with the T2 to T3 changes in OVB as the dependent variable and the T2 to T3 changes in vertical dentoskeletal mandibular parameters as the independent variables (FH to mandibular plane, S-Go/N-Me, Co-Go, and L6 vertical). The goal of this analysis was to evaluate whether the changes in overbite at the pubertal growth spurt were related to changes in mandibular structures. It is known that dentoskeletal mandibular components can be affected significantly by growth changes at puberty.[19,28]

Logistic regression and multiple linear regression analyses were carried out with statistical software (version 17.0, SPSS, Chicago, Ill).

RESULTS

Descriptive statistics for the cephalometric measurements at the 4 observation periods are reported in Table I, along with the statistical comparisons among the stages. No significant growth changes were detected in the cranial base angle.

In the maxillary skeletal measurements, SNA increased significantly both between T1 and T2 (1.4°) and during the overall observation interval T1 to T4 (1.6°). Point A to nasion perpendicular increased significantly (1.4 mm) only during the prepubertal T1 to T2 interval, and Co-A increased significantly at all growth intervals with the exception of the postpubertal T3 to T4 interval.

In the mandibular skeletal measurements, SNB increased significantly both between T1 and T2 (1.3°) and during the overall observation interval T1 to T4 (2.1°). Pogonion to nasion perpendicular increased significantly only during the prepubertal T1 to T2 (3.0 mm) interval and the overall T1 to T4 interval (3.0 mm), whereas Co-Gn increased significantly at all growth intervals.

In the maxillary-mandibular measurements, no significant growth changes were detected for the ANB angle or the Wits appraisal. Significant increments in the maxillary-mandibular differential were found during the prepubertal, pubertal, and overall growth intervals.

In the vertical skeletal measurements, no significant growth changes were evident relative to the inclination of the palatal plane to the Frankfort horizontal, whereas the inclination of the mandibular plane to the Frankfort

Table I. Descriptive statistics for cephalometric measurements at the 4 observation periods

	T1		*T2*		*T3*		*T4*		*Growth changes and statistical comparisons*			
Cephalometric measures N = 29	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*T1-T2 prepubertal*	*T2-T3 pubertal*	*T3-T4 postpubertal*	*T1-T4 overall*
Cranial base												
NSBa (°)	130.2	4.6	130.1	4.8	130.4	4.7	130.2	5.1	−0.2	0.4	−0.3	0.0
Maxillary skeletal												
SNA (°)	80.6	2.7	82.0	3.1	81.9	3.4	82.2	3.1	1.4*	−0.1	0.2	1.6*
Pt A to nasion perp (mm)	−0.3	3.1	1.1	3.1	0.9	3.7	0.1	3.8	1.4*	−0.2	−0.8	0.4
Co-Pt A (mm)	83.8	3.6	89.1	4.0	92.8	4.1	93.5	4.8	5.3*	3.7*	0.8	9.8*
Mandibular skeletal												
SNB (°)	76.7	2.0	78.0	2.8	78.5	2.9	78.8	2.8	1.3*	0.5	0.3	2.1*
Pg to nasion perp (mm)	−6.6	4.9	−3.6	4.9	−2.5	5.9	−3.6	6.5	3.0*	1.1	−1.0	3.0*
Co-Gn (mm)	105.9	3.9	111.6	4.0	121.2	5.0	122.9	5.4	5.9*	9.6*	1.7*	17.4*
Maxillary/mandibular												
ANB (°)	3.9	1.8	4.0	1.6	3.5	2.1	3.4	2.1	0.1	−0.5	−0.1	−0.5
Wits (mm)	0.3	2.2	0.9	1.7	1.2	2.7	1.8	3.0	0.5	0.2	0.6	1.4
Max/mand diff (mm)	20.1	2.5	23.1	3.5	26.2	4.2	25.7	4.3	3.0*	3.0*	1.5	7.7*
Vertical skeletal												
FH to palatal plane (°)	−2.2	3.2	−2.0	2.7	−1.2	3.0	−1.2	3.2	0.2	0.8	0.0	1.0
FH to mandibular plane (°)	23.3	3.6	21.6	4.2	19.9	4.0	19.5	4.1	−1.7*	−1.7*	−0.4	−3.8*
Palatal pl. to mand. pl. (°)	21.1	4.2	19.5	3.4	18.7	4.1	18.3	4.1	−1.6*	−0.9	−0.4	−2.8*
N-ANS (mm)	48.8	2.4	52.7	2.6	55.7	3.1	55.7	3.0	3.9*	2.9*	0.0	6.9*
ANS-Me (mm)	57.0	4.4	60.2	4.9	63.0	5.4	64.8	6.3	3.1*	2.9*	1.8*	7.9*
N-Me (mm)	106.5	5.3	113.7	5.5	119.8	7.1	121.8	8.0	7.2*	6.0*	2.1	15.2*
S-Go (mm)	64.5	4.0	70.2	4.6	75.3	5.2	78.1	6.3	5.7*	5.1*	2.8	13.6*
S-Go/N-Me (%)	65.5	0.03	66.8	0.04	68.0	0.04	69.3	0.04	1.3*	1.2*	1.3*	3.8*
Co-Go (mm)	51.6	2.9	56.2	3.7	60.9	3.6	63.6	4.6	4.5*	4.8*	2.6	12.0*
ArGoiMe (°)	120.3	5.3	118.0	4.9	116.5	5.1	114.8	5.1	−2.3*	−1.5	−1.7	−5.5*
Interdental												
Overjet (mm)	4.1	1.2	4.2	1.3	4.4	1.7	4.5	1.7	0.2	0.2	0.1	0.4
Overbite (mm)	5.5	0.6	6.3	0.8	4.6	1.2	4.2	1.0	0.8*	−1.6*	−0.4	−1.3*
Molar relationship (mm)	−0.4	1.6	0.3	1.4	0.6	1.7	0.6	1.6	0.8*	0.3	0.0	1.1*
Maxillary dentoalveolar												
U1 to FH (°)	108.5	7.0	107.3	6.9	107.7	7.7	107.6	9.0	−1.2	0.4	−0.1	−0.9
U1 vertical (mm)	24.9	2.2	26.4	2.8	26.8	3.1	27.3	2.9	1.3*	0.5	0.5	2.4*
U6 vertical (mm)	17.6	1.8	19.7	1.9	21.9	2.3	23.1	2.7	2.2*	2.3*	1.2*	5.5*
Mandibular dentoalveolar												
L1 to mandibular plane (°)	96.1	5.5	97.3	5.5	98.1	6.4	97.2	7.2	1.2	0.7	−0.8	1.1
L1 vertical (mm)	30.9	2.1	32.7	2.6	33.9	2.8	34.7	3.1	1.8*	1.2*	0.6	3.8*
L6 vertical (mm)	21.4	1.4	24.3	2.1	25.9	2.7	27.2	3.0	2.9*	1.6*	1.3*	5.8*

*$P < 0.05$.

horizontal had significant decreases during the prepubertal, pubertal, and overall growth intervals. These changes were reflected also by the inclination of the palatal plane to the mandibular plane. The N-ANS, ANS-Me, N-Me, S-Go, Co-Go, and S-Go/N-Me variables exhibited significant increases during the prepubertal, pubertal, and overall growth intervals, with the ANS-Me and S-Go/N-Me measurements showing significant increases also during the postpubertal interval. The gonial angle (ArGoiMe) exhibited a significant decrease during the prepubertal (−2.3°) and overall (−5.5°) intervals.

In the interdental measurements, overjet did not show a significant growth change. Overbite showed a significant increase during the prepubertal growth interval (0.8 mm), but a significant decrease during the pubertal growth interval (−1.6 mm); this contributed to a significant decrease during the overall observation interval (−1.3 mm). The molar relationship had a significant increase during the prepubertal interval (0.8 mm) and during the overall interval (1.1 mm), thus showing an increased mesial relationship of the molars with growth.

In the maxillary dentoalveolar measurements, a significant vertical eruption of the central incisors was found during the prepubertal and overall growth intervals. The first molars moved downward significantly at all observation intervals.

In the mandibular dentoalveolar measurements, the central incisors showed vertical eruption during the prepubertal and overall observation intervals. The vertical eruption of these teeth continued also during the pubertal growth interval. The first molars exhibited significant eruption at all growth intervals.

The analysis of the prevalence rates of deepbite subjects with either improvement or worsening in overbite during the growth intervals (Table II) showed that no subjects improved during the prepubertal T1 to T2 interval, whereas 62% of the subjects had a worsened overbite greater than or equal to 0.5 mm. When the pubertal T2 to T3 interval was included in the observation interval (T1-T3), the prevalence rate for subjects showing improvement in overbite greater than or equal to 0.5 mm was 79%; 28% of the subjects showed improvement greater than or equal to 1.5 mm. Only 10% of the subjects had a worsened overbite during the T1 to T3 interval.

The analysis of the overall T1 to T4 observation period showed that 83% of the subjects who started the observation interval with a deepbite had an improvement in overbite greater than or equal to 0.5 mm when reevaluated at young adulthood. A prevalence rate of 41% of the subjects showed improvement in overbite greater than or equal to 1.5 mm during the overall observation interval, and no subject had a worsened vertical overlap of the incisors. As for correction of overbite (OVB $\leq$4 mm), no deepbite subject achieved overbite correction at T2, 52% of the subjects attained overbite correction at T3, and 62% of the subjects showed overbite correction at T4.

Logistic regression on the cephalometric variables at T1 with the value of OVB at T4 (classified as "self-corrected" when OVB was $<$4 mm vs "not corrected," when OVB was still $>$4 mm) as the dependent variable had a classification power of 79%. The predictive variable at T1 for favorable or unfavorable individual outcomes in OVB was the inclination of the maxillary incisor to the Franfort horizontal.

Multiple regression analysis with the T2 to T3 changes in OVB as the dependent variable and the T2 to T3 changes in vertical dentoskeletal mandibular parameters as the independent variables showed that the changes in OVB at the pubertal growth spurt were significantly related to changes in ramus height (Co-Go, $P = 0.044$) and the vertical eruption of the mandibular first molars (L6 vertical, $P = 0.018$).

DISCUSSION

We evaluated the growth changes in orthodontically untreated subjects with deepbite (overbite $>$4.5 mm at an average age of about 9 years) followed longitudinally until young adulthood. Peculiar features of this study with respect to previous appraisals of dentoskeletal changes in subjects with deepbite were (1) the specific focus on deepbite regardless of sagittal relationships (contributions of the past mainly analyzed changes in overbite in Class II Division 1 patients)[3,29]; (2) a true longitudinal study with an adequate sample size (previous reports were either semilongitudinal[5] or analyzed small deepbite subsamples of larger longitudinal studies on overbite changes)[10,13]; and (3) the definition of growth intervals with a biologic indicator of skeletal maturity (this additional methodology allowed changes in overbite to be evaluated in relation to developmental growth changes and not only in relation to chronologic age intervals).

Overbite (as evaluated by the cephalometric variable OVB), which is the main indicator for deepbite subjects, showed a significant reduction from 9 through 18 years of age. The average reduction in overbite was 1.3 mm. The trend for improvement of overbite along with growth and aging was reported also by previous studies.[5,10,13,18]

A significant increase in the vertical overlap of the incisors in deepbite subjects was observed during the prepubertal ages (0.8 mm on average, with 3 of 5 subjects showing worsened OVB). Those who observed similar changes in overbite in previous studies attributed the changes mainly to the exfoliation of the deciduous teeth and the tooth eruption sequences during the mixed dentition phase.[5,9,13] No subject examined in our study attained self-correction of the deepbite at the end of the prepubertal growth period at an average age of 12 years, when they were in the late mixed or early permanent dentition.

During the adolescent pubertal growth period (CS3-CS5, during the transition from early to full permanent dentitions), a significant change in overbite occurred in most of our subjects. The average improvement in overbite was 1.6 mm, with almost 80% of the subjects showing improvement in overbite from T1 to T3. Almost 30% of the subjects showed a large improvement in overbite ($>$1.5 mm) from T1 to T3. Over half of the subjects with deepbite at T1 attained self-correction of the deepbite by T3, at the mean age of 15 years.

When the vertical dentoskeletal mandibular changes associated with these significant variations in overbite at puberty were evaluated with multiple regression analysis, the 2 cephalometric variables whose changes appeared related to the improvement in overbite were vertical growth of the mandibular ramus and amount of dentoalveolar vertical development at the level of the mandibular first molars. The regression analysis

Table II. Prevalence rates for deepbite subjects showing improvement, worsening, or correction of OVB during the growth intervals

	T1-T2 *% of subjects*	*T1-T3* *% of subjects*	*T1-T4* *% of subjects*
Improvement in OVB ≥ -1.5 mm (more negative change)	0	28	41
Improvement in OVB ≥ -0.5 mm (more negative change)	0	79	83
Worsening in OVB $\geq +0.5$ mm (more positive change)	62	10	0
Corrected OVB ($\leq$4 mm) at the end of the observation interval	0 (at T2)	52 (at T3)	62 (at T4)

focused on mandibular measurements, since it is known that mandibular structures are sensitive to changes concurrent with the adolescent growth spurt.[19,28] The use of a biologic indicator of skeletal maturity to define growth intervals allowed probably for the identification of skeletal changes in the mandibular ramus, including the condylar region. This type of outcome was not elicited in previous studies that used chronologic age to define the observation intervals.[3,5,13,14,18] The vertical eruption of the mandibular first molars in subjects showing improvement in overbite during puberty already had been postulated as an effective dentoalveolar mechanism associated with overbite changes in growing subjects.[13] Interestingly, angular parameters or ratios for skeletal vertical relationships (FH to mandibular plane and S-Go/N-Me) that are used classically to indicate facial divergence were not good predictors for the changes in overbite during puberty. A similar result was found by Bishara and Jakobsen[13] in their longitudinal study of overbite variations from 5 to 45 years of age. Also, the increased overbite at T1 was associated with the characteristics of skeletal deepbite. The values for S-Go/N-Me and for palatal plane to mandibular plane measurements at T1 were similar to those described for subjects with skeletal deepbite in the longitudinal studies by Nanda.[30,31]

The overall observation period, from before puberty through young adulthood, provided outcomes in terms of changes in overbite that were similar to those described for the pubertal growth interval, thus confirming the relevant role of the changes at puberty on the overall overbite variations in subjects with deepbite. The postpubertal growth period showed a slight continued improvement in overbite (0.4 mm). At young adulthood (average age, about 18 years), none of the examined deepbite subjects had a worsened overbite, but 4 of 5 subjects had some improvement in overbite, and, in 2 of 5 subjects, the improvement exceeded 1.5 mm. These data indicate a high prevalence of self-correction of deepbite (3 of 5 subjects) by young adulthood.

The significant cephalometric feature associated with the self-correction of overbite in deepbite subjects was the proclination of the maxillary incisors at the prepubertal observation, shown by logistic regression analysis. The deepbite subjects with reduced inclination of the maxillary incisors at 9 years of age had the smallest improvements in overbite during the subsequent developmental intervals. When these outcomes are applied to the analysis of subjects with Class II malocclusions, they suggest that outcomes in terms of overbite at the end of the growing period might be different in subjects with Class II Division 1 malocclusion (classically showing proclination of the maxillary incisors) vs subjects with Class II Division 2 malocclusion (classically showing retroclination of the maxillary incisors). Although specific investigations on larger longitudinal samples of Class II subjects are needed to draw definitive conclusions, in this study, 63% of the Class II Division 1 subjects attained self-correction of the initial deepbite by T4, whereas only 25% of Class II Division 2 subjects had favorable outcomes at T4.

Our results provide some potential indications for treatment planning in patients with a deepbite. The significant tendency for worsening of the deepbite during the prepubertal period and for improvement of the overbite during the pubertal and postpubertal developmental periods suggests that patients having orthodontic treatment for an increased overbite at an early stage (prepubertal, early mixed dentition) might be at risk of relapse during the late mixed dentition and before the onset of puberty. The classic long-term longitudinal study by Little et al[32] reported previously that, in deepbite patients treated during the mixed dentition (mean age, 10 years), "overbite response was typically a treatment decrease followed by a significant increase in the direction of the original deeper overbite." On the other hand, when approaching deepbite patients during the late growing ages, a clinician can make a more realistic diagnostic evaluation of the amount of overbite that requires therapeutic correction. More importantly, orthodontic treatment of excessive overbite at pubertal or postpubertal ages could benefit from the natural tendency of the dentition for spontaneous improvement in overbite that might counteract the relapse tendency. Simons and Joondeph[33] found already that "deep bite patients of either sex in whom overbite reduction was accomplished during their respective pubertal growth spurt periods maintained this correction 10 years postretention. Thus, it would be advisable for the clinician to be aware of individual differences in the onset of maximum growth velocity and to utilize this information in treatment planning." The long-term stability of deepbite treatment results was good also for the sample investigated more recently by Schütz-Fransson et al,[21] who had started treatment at puberty, with a mean age of 12.2 years for the patients starting treatment. A specifically designed clinical trial is required, however, to compare possible outcomes and stability in early vs late treatment of growing deepbite patients.

CONCLUSIONS

This longitudinal study on dentofacial growth changes in subjects with an increased overbite (deepbite subjects) showed the following.

1. Overbite worsened in 62% of the subjects during the prepubertal period (mixed dentition) and improved in 79% of the subjects at puberty (in the transition from late mixed or early permanent dentition to full permanent dentition). From prepubertal ages through young adulthood, overbite showed improvement in 83% of the subjects and self-correction in 62% of the subjects.
2. Improvements in overbite cannot be predicted on the basis of skeletal vertical relationships.
3. A significant positive association was found between the initial amount of maxillary incisor proclination and the prevalence rate of self-correction in overbite.
4. The significant improvement in overbite during the adolescent growth spurt appeared to be related to the amount of vertical growth of the mandibular ramus and the eruption of the mandibular molars.
5. The growth changes in deepbite subjects provide indications for the timing of orthodontic treatment of an increased overbite.

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