Alveolar and skeletal dimensions associated with overbite

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The aim of this study was to investigate whether in the maxilla and in the mandible the structure of the anterior medial sagittal alveolar and basal bone is related to the overbite. A total of 460 untreated adult subjects were divided into four groups with either deep bite, normal overbite, end-to-end bite, or open bite and were compared. The overbite, lower face height, and anterior alveolar and basal midsagittal cross-sectional areas from the maxilla and the mandible were assessed on lateral cephalometric radiographs. An index was calculated, dividing the sagittal by the vertical dimension of the midsagittal cross-sectional area. A deeper bite coincided with smaller lower face height, larger alveolar and basal areas, and a more widened shape of the symphysis. If the lower face height was introduced as a covariable, the open bite group showed significantly smaller maxillary and mandibular alveolar and basal cross-sectional areas compared with the end-to-end group, the normal overbite group, or the deep bite group. Vertical variation of the overbite probably coincides with a relative hyperdevelopment or hypodevelopment of the symphysis. (Am J Orthod Dentofacial Orthop 1998;113:443-52.)

An open bite can be found in Angle Classes I, II, Division 1, and III malocclusions.[1] Generally, two different forms of open bite can be distinguished. In the dentoalveolar open bite, morphologic abnormalities are confined to the dentoalveolar region.[2-5] This type of open bite is often related to habits such as thumb sucking and tongue-thrusting.[3,4,6] The structure of the skeletal open bite is more complex. The abnormal skeletal pattern is not limited to the dentoalveolar region[2,3] and is frequently described as "long-face syndrome"[7,8] or a "high-angle case."[9,10] Many articles have dealt with cephalometric comparisons between groups of patients with open bite and normal overbite. Mainly, an open bite was defined as lack of vertical overlap between the incisors; whereas, a normal overbite was defined as a certain amount of overlap between the incisors. Some features described as being characteristic for the skeletal open bite, compared with patients with a normal vertical skeletal pattern are larger lower facial height,[2,3,5,6,11-17] smaller upper/lower anterior face height ratio,* smaller posterior facial height,[5,6,12,13,16] a large angle between the cranial base and the mandibular plane,† and a more obtuse gonial angle.[2,3,5,6,11,17]

Some investigators recorded a larger dentoalveolar height in the frontal part of both jaws in patients with open bite, compared with patients with a normal or deep bite.[3,21] Several authors[11,12,14,15] reported significant differences between patients with normal and deep bites in the dentoalveolar region of the maxilla only. Others[18] found no differences at all, and two authors[5,20] recorded a slightly smaller dentoalveolar height of the incisor region in patients with open bites. According to some authors,[7,9,16] a normal overbite can be associated with excessive vertical facial dimensions.

A relationship may exist between the structure of the frontal part of the maxilla and the mandible and the lower face height, in such a way that, in cases with an open bite or a deep bite, the vertical dentoalveolar development may be insufficient to compensate for the large or small distance between the jaws. This possible relationship is illustrated in Fig. 1.

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*References 2,3,5,6,11,13,18,19.

†References 2,5,6,11-13,15,16,18,20,21.

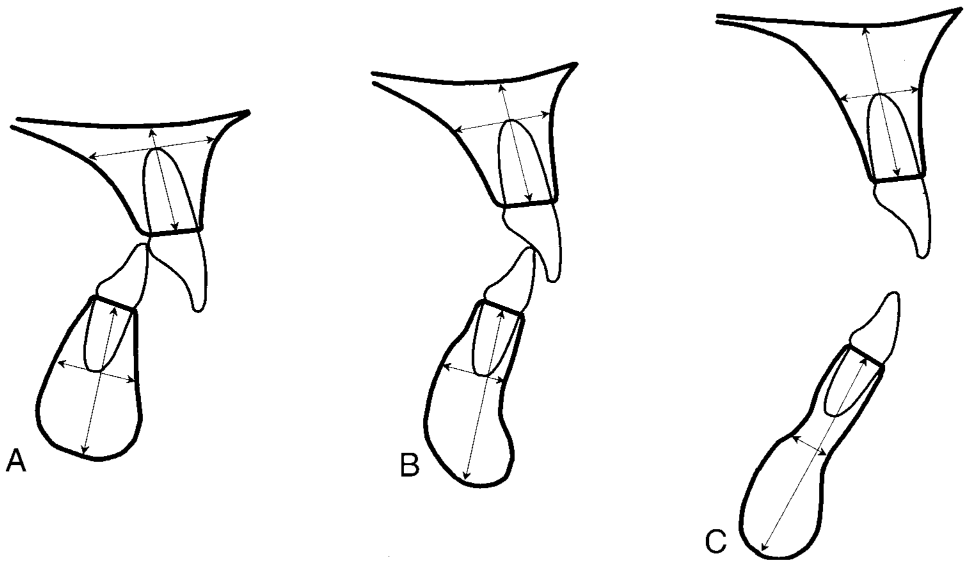

Fig. 1. Different projections of frontal alveolar and basal bone in three cases with deep bite, average overbite, and open bite. **A,** Midsagittal projection of frontal alveolar and basal bone in subject with deep bite. Alveolar and basal depth is large, whereas alveolar height is small. **B,** Midsagittal projection of frontal alveolar and basal bone in subject with normal overbite. Proportions between alveolar and basal depth and height are normal. **C,** Midsagittal projection of frontal alveolar and basal bone in open bite subject. Alveolar and basal depth is smaller, whereas alveolar height is larger; nevertheless, there is insufficient compensation.

A discrepancy between the vertical dimensions of the alveolar and basal bone on the one hand and the vertical dimensions of the lower anterior face on the other hand may reflect an abnormal vertical position of the incisors and thereby influence the overbite.

Observations on long-faced patients often demonstrate a narrow and elongated midsagittal projection of the maxilla and the mandible. This suggests a compensatory mechanism simultaneously enlarging the vertical dimensions while reducing the labiolingual dimensions of the basal and alveolar bone in the frontal part of both jaws in such a way that a normal or deep bite can occur even in people with long faces[22,23] (see Fig. 1, *A* and *B*). Thus the structure of the alveolar and basal bone may be useful for predicting the treatment success of overbite problems.

As it seems that the overbite is not necessarily related to the lower face height, this study was performed to investigate whether the form and size of the anterior region in the maxilla and the mandible in untreated persons are related to the overbite.

Special measurements were developed to investigate the form and size of the alveolar and basal bone in the anterior region of both jaws, including area measurements. The following hypothesis was tested: The size and the form of the frontal midsagittal alveolar and basal bone of the maxilla and the mandible are related to the overbite.

MATERIAL AND METHODS

Pretreatment cephalograms of 460 adults (191 men and 269 women) were selected from a larger sample of 4200 cephalograms from the archives of the orthodontic departments at the Academisch Centrum Tandheelkunde Amsterdam (ACTA) and the academic hospital Dijkzigt in Rotterdam and from the archives of the department of oral surgery at the academic hospital of the Vrije Universiteit, Amsterdam. All cephalograms included in the study were taken of persons of white European origin. The female patients were older than 17 years and the male patients were older than 19 years. No subject had severe craniofacial disorders, such as cleft palate or extensive prosthetic appliances. Presence of at least one premolar and one molar in each quadrant, as well as all maxillary and mandibular anterior teeth, was required. Consequently, the sample included some patients in whom teeth were extracted but who did not undergo orthodontic treatment. Occlusal contact was required between at least one maxillary and one mandibular molar or premolar.

Twenty-four landmarks were digitized, with a GTCO-

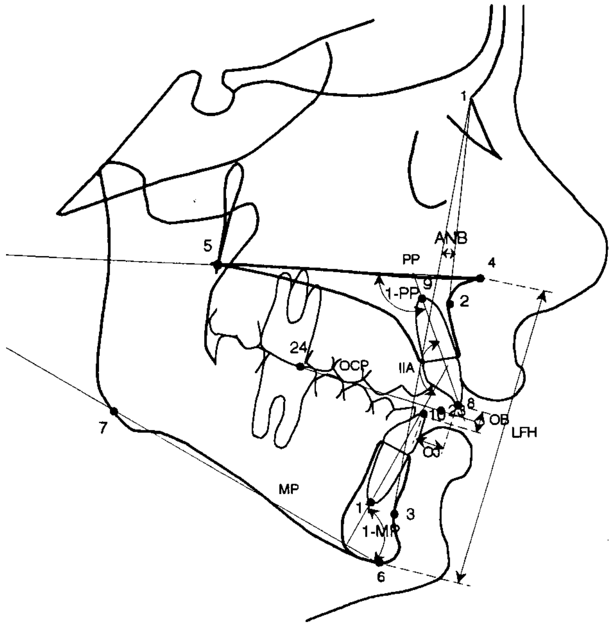

Fig. 2. Skeletal cephalometric landmarks, reference lines, and measurements used in study. Landmarks: Points 1-11 are defined according to Riolo.[24] 1: Nasion, junction of frontal, maxillary and nasal bones; 2: A-point, deepest point of curvature of frontal midsagittal section of maxilla; 3: B-point, deepest point of curvature of frontal midsagittal section of mandible; 4: anterior nasal spine, tip of median sharp long process of maxilla at lower margin of anterior nasal opening; 5: posterior nasal spine, most posterior point at sagittal plane on bony hard palate; 6: menton, most inferior point on symphysial outline of chin; 7: Gonion, midpoint of angle of mandible found by bisecting angle at mandibular plane and plane through Articulare, Posterior and along portion of mandibular ramus inferior to it; 8: incisal tip of central maxillary incisor; 9: apex of central maxillary incisor; 10: incisal tip of central mandibular incisor; 11: apex of central mandibular incisor; 23: frontal point of occlusal plane (midpoint between incisal tips of maxillary and mandibular central incisors); 24: dorsal point of occlusal plane (midpoint between mesiobuccal cusps of maxillary and mandibular first molars). Reference lines: *MP*: Mandibular plane, line connecting menton and gonion, defined according to Fields,[7] Schendel,[16] Prahl,[26] and Janson.[36] *PP*: Palatal plane, connecting posterior and anterior nasal spine. *OCP*: Occlusal plane, connecting midpoints between incisal ridges of central incisors and midpoint between mesiobuccal cusps of first molars. Measurements: *LFH*: Lower face height, direct distance between Anterior Nasal Spine and Menton. *ANB*: Sagittal jaw angle, angle between lines NA and NB. *OB*: Overbite, distance between incisal tips of maxillary and mandibular central incisor perpendicular to occlusal plane. Positive values for overbite indicated normal or deep bite, whereas open bite was indicated by negative values. *OJ*: Overjet, distance between incisal tips of maxillary and mandibular central incisor parallel to occlusal plane. *IIA*: Interincisal angle, angle between axes of maxillary and mandibular incisors. *1-PP*: Inclination of maxillary central incisor to palatal plane, dorsal angle between axis of maxillary central incisor and palatal plane. *1-MP*: Inclination of mandibular central incisor to mandibular plane, ventral angle between axis of mandibular central incisor and mandibular plane.

digitizer (CTCO Corp), which was connected to a 486DX-33 PC (Hewlett Packard). Most landmarks were defined according to Riolo[24] and Steiner.[25] A software package developed at the department of orthodontics of the ACTA, especially for this study, was used for storage of the landmark coordinates and calculation of the measurements. Three reference lines were established and 15 measurements computed. Four landmarks were constructed as support for measurements or constructing surfaces.

The landmarks, reference lines, and measurements are described in Figs. 2 and 3.

Differences between the overbite groups and between genders were assessed by means of a Multivariate Analysis of Covariance. For this statistical analysis, the subjects

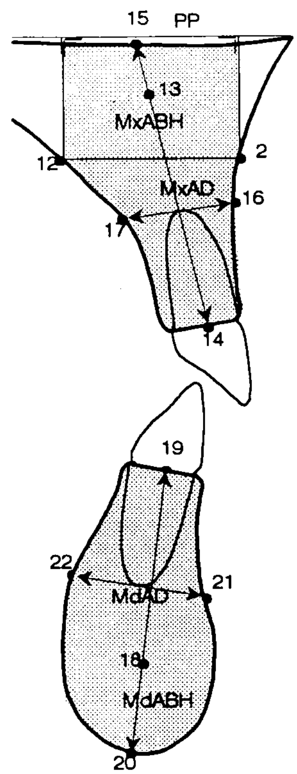

Fig. 3. Illustrations of dentoalveolar cephalometric landmarks, reference lines, and measurements used in study. Landmarks: 12: palatal counterpart of A point (2) on palatal cortical bone at same distance from palatal plane as A point. 13: center of rectangle limited by line 2-12 and palatal plane. Rectangle represents midsagittal section of basal bone of maxilla. This point was defined as center point of maxillary alveolus. 14: Midpoint of alveolar meatus of maxillary central incisor. 15: Intersection between palatal plane and maxillary alveolar axis (maxillary alveolar axis runs from midpoint of alveolar meatus of maxillary central incisor through center point of maxillary alveolus.) 16: Frontal point of shortest line above apex of maxillary central incisors between maxillary midsagittal labial and palatal alveolar cortical bone. 17: Dorsal point of shortest line above apex of maxillary central incisors between maxillary midsagittal labial and palatal alveolar cortical bone. 18: center point of basal midsagittal bone of mandible (point D according to Steiner[25]). 19: midpoint of alveolar meatus of mandibular central incisor. 20: intersection between symphysial surface and mandibular alveolar axis (mandibular alveolar axis runs from midpoint of alveolar meatus of mandibular central incisor through center point of symphysis.) 21: Frontal point of shortest line above apex of mandibular central incisors between mandibular midsagittal labial and lingual alveolar cortical bone. 22: Dorsal point of shortest line below apex of mandibular central incisors between mandibular midsagittal labial and lingual alveolar cortical bone. Measurements: *MxABH*: Maxillary alveolar and basal height, distance between midpoint of alveolar meatus of maxillary central incisor and intersection between palatal plane and maxillary alveolar axis. *MdABH*: Mandibular alveolar and basal height, distance between midpoint of alveolar meatus of mandibular central incisor and intersection between symphysial surface and mandibular alveolar axis. *MxAD*: Maxillary anterior depth, defined as distance between points 16 and 17. *MdAD*: Mandibular alveolar depth, defined as distance between points 21 and 22. MxABA: Area of alveolar and basal midsagittal cross-section of maxillary jaw. Line was drawn perpendicular to palatal plane, intersecting point A (9) and forming anterior border of maxillary alveolar and basal area. From point A, line was drawn parallel to nasal plane intersecting dorsal contour of maxillary alveolar bone (10). Dorsal border of maxillary basal area was formed by line, perpendicular to nasal plane, intersecting point 10. Area was then measured between these lines and outer contour of maxillary alveolar and basal bone below line 2-12. MdABA: Area of alveolar and basal midsagittal cross-section of mandible, area between outer contour of symphysis. Both areas are shaded.

Table I. Differences between DB, EE, NB, and OB patients

	DB group N = 156			NB group N = 144			EE group N = 73			OB group N = 87				Differences		
Variables	*Mean*	*SD*	*Adjusted mean*	*Mean*	*SD*	*Adjusted mean*	*Mean*	*SD*	*Adjusted mean*	*Mean*	*SD*	*Adjusted mean*	*Multivariate F-test*	*DB-NB*	*NB-EE*	*EE-OB*
MxABA	214.62	59.51	246.60	222.67	57.76	233.73	224.19	66.25	221.29	215.48	49.29	195.08	19.58***	*	*	***
MdABA	337.83	64.86	365.17	330.68	62.14	342.31	326.95	63.18	324.24	303.16	57.75	288.20	32.50***	***	*	***
MxABH	19.63	3.84	22.71	20.13	3.30	20.61	20.83	4.08	20.39	21.34	3.21	19.38	18.13***	***		*
MxAD	12.48	3.07	11.69	12.21	2.85	12.27	11.45	2.62	11.77	10.44	2.53	11.44	2.10			
MdABH	32.25	4.39	35.62	33.03	3.94	34.00	33.90	4.56	33.34	33.76	3.71	31.37	58.44***	***	*	***
MdAD	8.34	1.72	7.65	7.99	2.00	7.86	7.14	1.79	7.31	6.17	1.63	6.77	6.58***		*	
MxAI	0.67	0.25	0.54	0.63	0.21	0.62	0.58	0.20	0.61	0.50	0.16	0.62	4.51**	***		
MdAI	0.27	0.07	0.22	0.25	0.08	0.24	0.22	0.07	0.23	0.19	0.06	0.22	2.45	*		
Interincisal angle	137.30	21.56	135.42	130.37	10.50	130.35	129.08	10.71	129.54	126.40	12.93	128.07	3.68*	**		
Overjet	7.40	3.73	7.40	4.78	3.39	4.84	3.25	3.22	3.22	4.36	4.94	4.11	19.23***	***	**	
ANB	4.59	2.58	5.17	2.89	2.92	3.08	2.20	3.85	2.00	2.08	5.22	1.40	18.12***	***	*	
1-PP	109.54	15.74	106.79	110.61	8.69	110.13	111.74	7.88	112.48	114.26	6.99	116.77	10.59***	*		*
1-MP	86.53	10.44	87.73	87.24	8.88	87.50	90.06	7.80	89.84	93.79	10.42	92.93	4.90**			

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
DB: Deep bite group; *EE:* end-to-end overbite group; *NB:* normal overbite; *OB:* open bite group.

were divided into four groups on the basis of the overbite. The four groups were as follows:

1. Open bite group: Overbite being smaller than or equal to –1 mm.
2. Edge-to-edge overbite group: The overbite being more than –1 mm but less than or equal to +1 mm.
3. Normal overbite group: The overbite being more than +1 mm but less than or equal to +4 mm.
4. Deep bite group: The overbite being more than +4 mm.

The normal overbite group was defined after careful analysis of the literature.[26-29] To eliminate interactions between dimensions of the midsagittal cross-sectional areas of the jaws and the vertical dimensions of the face, the skeletal lower face height was used as covariate. The intergroup differences were compared, by using the repeated Bonferroni procedure. The repeated contrast method allowed the analysis of the differences between groups of cases with consecutively deeper bite.

The relative contributions of the size and the form of the alveolar and basal midsagittal bones to the variance of the overbite were assessed by means of regression analysis. The effects of the ANB angle, the overjet, and the inclination of the incisors of the maxilla and the mandible on the alveolar and basal areas and on the alveolar indices of the maxilla and the mandible were also assessed by means of regression analyses.

The tracing and digitizing process of the cephalogram was repeated by an independent observer for 33 subjects. The time span between these independent tracings and recordings from each of the 33 subjects was at least 6 weeks. Correlation coefficients for repeated measurements were calculated to test for the interobserver variability of the measurements. Students' t tests were performed between the first and the second group of recordings to detect any systematic difference between the first and the second tracings of the error study. For all statistical analyses, the confidence level $p < 0.05$ was considered significant.

Table II. Correlations between the overbite and all variables used in the study

Variables	*Pearson R*	*Partial R*
MxABA	−0.00	0.46***
MdABA	0.17***	0.49***
MxABH	−0.17***	0.37***
MxAD	0.22***	0.11*
MdABH	−0.17***	0.60***
MdAD	0.37***	0.14**
MxAI	0.24***	−0.09*
MdAI	0.34***	−0.07
LFH	−0.56***	—
Interincisal angle	0.40***	0.34***
OJ	0.30***	0.25***
ANB	0.28***	0.31***
1-PP	−0.23***	−0.35***
1-MP	−0.16**	−0.03

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Partial correlation: Covariable LFH.

RESULTS

Error Study

Correlation coefficients below 0.90 were found for the maxillary and basal alveolar height (0.87), the maxillary alveolar depth (0.69), the mandibular alveolar depth (0.86), and the maxillary alveolar index (0.80). For all other variables, the correlation coefficients were above 0.90. No significant differ-

Table III. Linear regression with r, r^2, and standard error

Variable	R	R^2	SE	B	β	T	p
LFH	0.56	0.31	3.57	−0.55	−1.21	−21.86	***
MdABA	0.69	0.48	3.11	0.03	0.42	10.11	***
MdAI	0.74	0.54	2.92	−20.38	−0.38	−8.02	***
MxABA	0.76	0.58	2.79	0.02	0.30	6.81	***
MxAI	0.77	0.59	2.77	−2.16	−0.11	−3.00	**
Constant				33.03			***

**$p < 0.01$; ***$p < 0.001$.
Dependent variable: Overbite. Independent variables: areas and alveolar indices. R, R^2, and SE display the values if the corresponding variables are added to the equation. B and β values are given for the total equation.

Table IV. Linear regression with r, r^2, and standard error

Variable	R	R^2	SE	B	β	T	p
LFH	0.56	0.31	3.57	−0.55	−1.22	−19.27	***
MdABH	0.75	0.56	2.84	0.67	0.65	15.38	***
MxIncPP	0.81	0.66	2.50	−0.08	−0.21	−3.76	***
Overjet	0.86	0.75	2.17	0.22	0.21	8.28	***
MxABA	0.88	0.77	2.09	0.02	0.27	8.68	***
Interincisal angle	0.88	0.77	2.06	0.07	0.27	3.68	***
MdincMP	0.88	0.78	2.05	−0.04	−0.10	−2.17	*
MxAI	0.88	0.78	0.77	−2.63	−0.14	−4.84	***
Constant				18.49			***

*$p < 0.05$; ***$p < 0.001$.
Dependent variable: Overbite. Independent variables: all variables used in the study. R, R^2, and SE display the values if the corresponding variables are added to the equation. B and β values are given for the total equation.

Table V. Linear regression with r and r^2

Dependent variable	Independent variables	R	R^2
MdAI	1-MP and ANB	0.45	0.20
MdABA	1-MP	0.28	0.08

Dependent variables: md. alveolar and basal area, md. alveolar index. Independent variables: ANB, OJ, 1-MP. R and R^2 are given for the total equation when all measurements are added to the regression equation.

ences ($p < 0.10$) between the first and the second group of tracings were found.

Multivariate Analysis of Covariance

No significant interaction effects between gender and overbite groups were found. Therefore the adjusted means for the different overbite groups include both male and female subjects.

All measurements showed an overall significant difference between the different overbite groups (Table I), except for the maxillary alveolar depth and the mandibular alveolar index.

The Bonferroni test for intergroup comparisons showed that groups with deeper overbite showed larger adjusted means for the maxillary and mandibular alveolar and basal areas, the maxillary and mandibular alveolar and basal heights, the mandibular alveolar depth, the interincisal angle, the ANB angle, and the overjet, compared with the groups with smaller overbite. The largest differences were found for the mandibular alveolar and basal area. All intergroup differences for the alveolar and basal areas and for the mandibular alveolar and basal height were significant. For the maxillary alveolar and basal height, differences were significant between the open bite (OB) and the end-to-end (EE) groups, as well as between the normal bite (NB) and the deep bite (DB) groups. For the ANB angle and the overjet, differences were significant between the EE and the NB groups, as well as between the NB and the DB groups. For the maxillary alveolar index and for the interincisal angle, differences were significant between the NB and the DB groups, whereas, for the mandibular alveolar depth, differences were significant between the EE group and the NB group.

Smaller adjusted mean values for the group with deep bite were found for the inclination of the maxillary central incisor to the palatal plane. The differences between the OB and the EE groups, as well as between the NB and the DB groups, were significant. Furthermore, the maxillary alveolar index showed smaller adjusted mean values for the DB group compared with the NB group.

The Bonferroni procedure could not reveal significant intergroup differences for the maxillary alveolar depth and the inclination of the mandibular central incisor to the mandibular plane. However, the multivariate test showed that groups with deeper bites had smaller adjusted mean values for the inclination of the mandibular central incisor to the mandibular plane, compared with the groups with smaller overbites.

Correlation Analyses

Pearson correlations were calculated between the overbite and all measurements used in the study (Table II). The largest correlations were found between the overbite and the lower face height (−0.56) and the interincisal angle (+0.40). All other correlation coefficients were below 0.40 and therefore not considered clinically important, although they still were significant.

Because the lower face height showed a strong relationship with the overbite, partial correlations were calculated with the lower face height as covariable. Then significant correlations were found with the maxillary and the mandibular alveolar and basal area (+0.46 and +0.49 respectively) and with the mandibular alveolar and basal height (+0.60). The other correlations were below 0.40 and therefore further evaluation was not considered necessary.

Regression analyses

To investigate the relation between the overbite, the lower face height, and the structure of the anterior alveolar and basal bone, the variables listed in Table III were taken into a multiple stepwise regression analysis. The results showed that 58.9% of the variance of the overbite (r = 0.77) could be explained mainly by a combination of the lower face height, the mandibular alveolar and basal area, the mandibular alveolar index, the maxillary alveolar and basal area, and the maxillary alveolar index. The results are shown in Table III. As the overbite decreases, the lower face height will be larger, the mandibular alveolar and basal area will be smaller and the shape of the symphysis will be wider and shorter. This can be deduced from the positive and negative B and β values. The contributions of the maxillary alveolar and basal area and of the maxillary alveolar index are very small, although they are still significant.

If all measurements were taken into the regression analysis, the variance of the overbite explained was higher (77.8%, r = 0.88) (Table IV). The measurements with significant correlations with the overbite were the lower face height, the mandibular alveolar and basal height, the inclination of the maxillary central incisor to the palatal plane, the overjet, the maxillary alveolar and basal area, the interincisal angle, the inclination of the central mandibular incisor to the mandibular plane, and the maxillary alveolar index. As the overbite decreases, the lower face height will be larger, the mandibular alveolar and basal height will be smaller, the maxillary central incisor will be more protruded, and the overjet will be smaller. The influence of the other measurements was small but significant.

No predictor variables were entered into the regression analysis, when an attempt was made to predict the maxillary alveolar index or the maxillary alveolar and basal area by a combination of the overjet, the ANB angle, or the inclination of the maxillary incisor to the palatal plane (Table V). For the mandible, it was possible to predict the mandib-

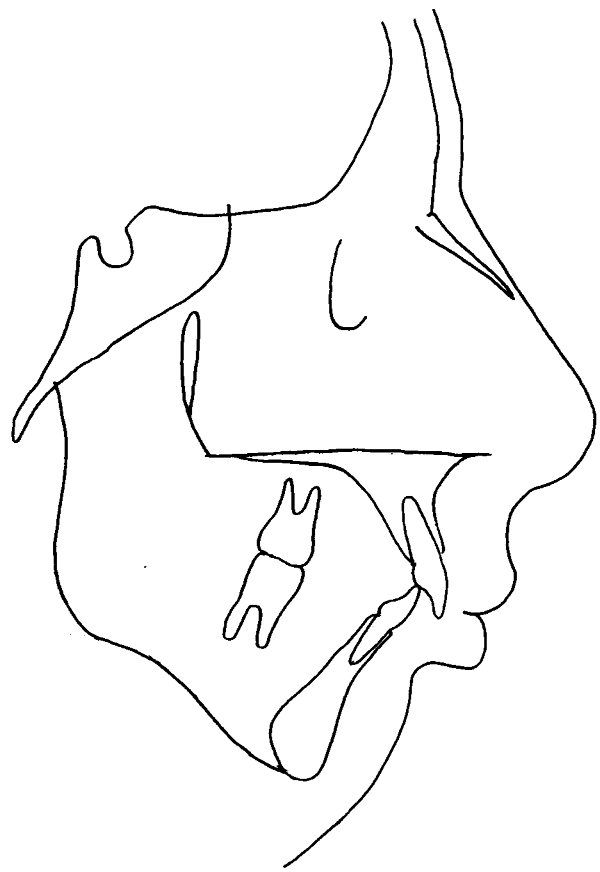

Fig. 4. Example of male patient with large lower face height and deep bite. DB group: age: 23 years; lower face height: 82.07 mm; MxABA: 355.03 mm^2; MdABA: 393.30 mm^2; MxAI: 0.46; MdAI: 0.18; overbite: 6.35 mm; IIA: 123.78°.

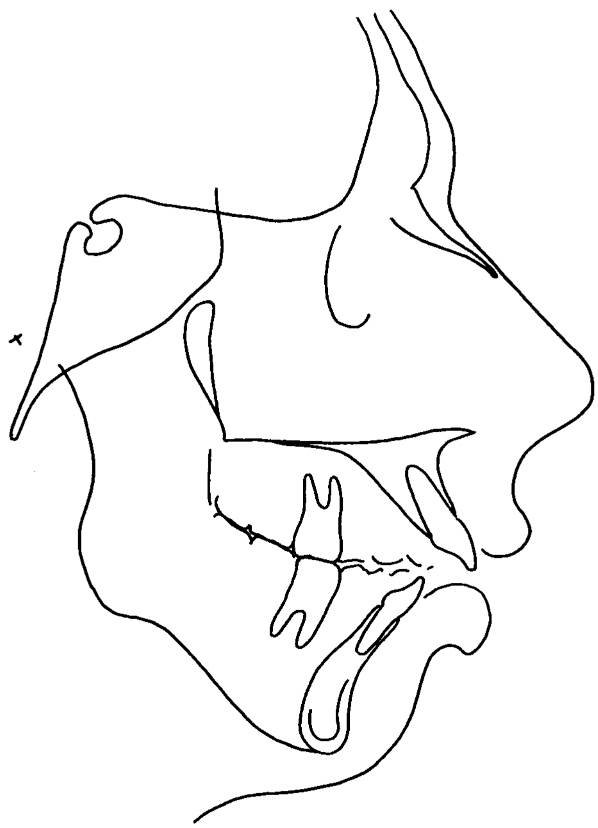

Fig. 5. Example of male patient with large lower face height and open bite. OB group: age: 26 years; lower face height: 81.71 mm; MxABA: 316.33 mm^2; MdABA: 312.95 mm^2; MxAI: 0.70; MdAI: 0.19; overbite: –1.41 mm; IIA: 109.30°.

ular alveolar index by a combination of the inclination of the mandibular incisor to the mandibular plane and the ANB angle (multiple r = 0.45). A small mandibular alveolar index was associated mainly with a retruded mandibular incisor and a large ANB angle. The mandibular alveolar and basal area was correlated to the inclination of the mandibular incisor to the mandibular plane (multiple r = 0.28). A small mandibular alveolar and basal area coincided with a retruded mandibular incisor.

DISCUSSION

Usually, the study of open bite is carried out by analyzing the differences between a selected group of patients with open bite with a control group.* The interactions between lower face height and other measurements that may influence the overbite are often not taken into consideration. This may be important because long-face patients can have a deep bite and patients with a normal face height can have an open bite. Therefore a different approach was chosen in this study, in which the lower face height was used as a covariate. In this way, the relationships between the overbite and the structure of the frontal alveolar and basal bone were investigated independently from the interaction effects of the lower face height. To achieve the true distance between the jaw bases, the direct distance between the anterior nasal spine and menton was measured.

The results of this study indicate that, apart from the lower face height, the dimensions of the mandibular symphysis have a certain impact on the overbite. The regression analyses showed that the lower face height and the overbite were negatively related; subjects with a deep bite generally had a smaller lower face height, whereas subjects with an open bite generally had a larger lower face height. This was also confirmed by previously reported findings.[5,6,11-15,30,32] Another study[33] showed that subjects with a short-face structure generally had a smaller area and a more widened and shortened shape of the symphysis. As the subjects of the deep bite group generally had a smaller lower face height, one would expect them to have slightly widened and shortened shapes, as well as a smaller area of the symphysis. However, this study revealed that in the deep bite group, the area of the symphysis generally was larger and the shape of the symphysis generally was slightly more narrowed and elongated. Although the cephalometric approach is only two-dimensional, this may indicate that the volume of the symphysis is smaller in subjects with an open bite and larger in subjects with a deep bite. The deep bite may have been due to the enlargement of the area of the symphysis and to a lengthening and narrowing of its shape. Only a slight relation was found between the dimensions of the corresponding maxillary frontal alveolar and basal bone and the overbite.

The feasibility of overbite correction by orthodontic treatment may thus be assessed by using the measurements (the alveolar and basal areas and indices, as well as the lower face height) as indicated in Table III. These relations are illustrated by two subjects from the sample (Figs. 4 and 5).

The inclination of the maxillary central incisor seems to have an effect on the overbite. This study showed that in subjects with an open bite, the maxillary central incisor generally is protruded, whereas in subjects with deep bite, the maxillary central incisor generally is more steeply inclined. The mandibular central incisor seems to be slightly

*References 2,3,5,6,12-15,30,31.

more protruded in the deep bite group, compared with the open bite group. The protrusion of the mandibular central incisor seems to be contradictory; however, the differences are very small and the mean values for the inclination of the mandibular central incisor to the mandibular plane are around 90° in all four overbite groups. Therefore a slight change in the inclination of the mandibular incisor will have no effect on its vertical height. However, in the maxilla, the central incisors, on the average, are protruded. Here a slight increase or decrease in the inclination of the central incisor will produce a larger effect on its vertical height.

In this study, the depth of the symphysis was measured only at the level of the apices of the central mandibular incisors, so it cannot be ruled out that the depth of the symphysis measured at another level (for example at the bony chin) may have a different relationship with the overbite. Haskell[34] measured the amount of protruding chin area as a percentage of total mandibular alveolar and basal area in subjects with open and normal or deep bites. He found that patients with open bite showed a smaller protruding chin area, related to their total mandibular alveolar and basal area. This may indicate that in patients with open bite, the base of the symphysis may be narrowed.

The maxillary alveolar index and the maxillary alveolar and basal area appear not to be influenced by the inclinations of the maxillary central incisors or by the sagittal jaw relations. In the mandible, there seems to be a small influence of the alveolar depth and of the alveolar and basal area on the inclination of the mandibular incisor, but their influences are contradictory. A small alveolar index, as can be expected in subjects with deep bite, coincides with a retrusion of the mandibular incisor. However, those who have a deep bite seem to have a slight protrusion of their mandibular incisors. The inclination of the mandibular central incisor probably has a slight effect on the mandibular alveolar index, but this effect does not influence the relationship between the alveolar index and the overbite. The overjet seems to have no influence on the mandibular alveolar index. The larger mandibular alveolar and basal area in subjects with deep bite could be partially explained by the protrusion of the mandibular incisor in cases with deep bite, but the correlation is very weak. The fact that the sagittal relation between the maxilla and the mandible does not influence the sagittal dimensions of the symphysis was also demonstrated by Nanda[35] who measured the depth of the symphysis (as well as its height) at two levels in cases with Angle Class I, Class II, and Class III malocclusions. By comparing the shape with the sagittal malocclusion, Nanda found that the sagittal occlusion was not related to the shape of the symphysis.

The measurements concerning the depth and the shape of the maxillary alveolar and basal bone should be interpreted with care, as these measurements showed the lowest reliability (below 0.90). This may be due to the definition of the maxillary alveolar and basal bone. The measurements concerning the area, depth. and shape of the mandibular alveolar and basal bone, however, seem to be reasonably reliable, as nearly all coefficients of reliability of these measurements are above 0.96. This may be expected because the outline of the symphysis can easily be traced from a cephalogram.

It was postulated in another article[33] that the size of the symphysis was determined by a factor distinct from the factors that control the lower face height. This article clearly showed that the size of the symphysis was related to the overbite. Maybe the factor that controls the size of the symphysis is an entity that acts more or less independently from the vertical dimensions of the lower face. This size controlling factor may also be the genetic factor determining the overbite. Therefore disharmonies between the effect of the size controlling genetic factor and the effect of the shape/lower face height controlling genetic factor may account for considerable variation in overbite in subjects with similar lower face height.

CONCLUSION

The size and form of the mandibular symphysis are related to the overbite in such a way that subjects with a deep bite generally show a large area and narrowed shape of the symphysis. This relationship becomes apparent after correction for the lower face height. In subjects with an open bite, the reverse is found. In contrast, the midsagittal alveolar and basal area and shape of the maxilla showed only a slight relation with the overbite. Thus an estimation of the feasibility of overbite correction by orthodontic treatment may be performed by using the area and the shape of the symphysis, along with the lower face height.

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