ORIGINAL ARTICLE

Alveolar and skeletal dimensions associated with lower face height

S. H. Beckmann, DDS,[a] R. B. Kuitert, DDS, PhD,[b] B. Prahl-Andersen, DDS, PhD,[c] D. Segner, DDS, PhD,[d] R. P. S. The, DDS,[e] and D. B. Tuinzing, DDs, PhD[f]
Amsterdam, The Netherlands, and Hamburg, Germany

In this study, the relationships between the lower face height and the structure of the frontal alveolar and basal bone were investigated. The areas and the dimensions of the anterior alveolar and basal midsagittal cross-sectional bone from the maxilla and the mandible were recorded on lateral cephalograms from 460 untreated adults. An index was calculated dividing the sagittal by the vertical dimension of the midsagittal cross-sectional area. The subjects with a normal overbite between 0.5 and 4 mm (N = 165) were divided into three groups according to the lower face height. A larger lower face height coincided with a larger maxillary alveolar and basal area and with a smaller mandibular alveolar index. Correlations between the lower face height and the maxillary alveolar index and the mandibular alveolar and basal area were low. It is concluded that long-faced subjects have a large mandibular alveolar height, which is more associated with a narrowed shape than with a large volume of the symphysis. (Am J Orthod Dentofacial Orthop 1998;113:498-506.)

In the cephalometric literature, the associations between the overbite and the vertical skeletal pattern have been described many times. Several descriptions of facial structure have been used, such as skeletal open bite,[1-5] skeletal deep bite,[2,3] long-face syndrome,[4,6] short-face syndrome,[7] high angle type,[8] low angle type,[9] hyperdivergent,[3] hypodivergent,[10] vertical maxillary excess,[8] vertical maxillary deficiency.[7] Cephalometrically, these descriptions are made on the basis of total and lower face height,[8] gonial angle,[4] ramus length,[4] mandibular plane angle,[8] and facial prognathism or retrognathism.[8] It has become increasingly clear that the cephalometric characteristics of a long-face structure are predominantly located below the palatal plane.[1,4,6]

Significant negative correlations between the lower face height and the overbite were found by Adams and Kerr[11] and Dung.[12] However, not all long-faced subjects have an anterior open bite.[4,8,12,13] Therefore not only the vertical facial skeletal dimensions but also the vertical size of the dentoalveolar region in the frontal parts of the jaws may be related to the overbite. This is suggested by Fleming,[14] who found significant positive correlations between the overbite and dentoalveolar height.

Observations on long-faced subjects demonstrate a narrow and elongated midsagittal projection of the maxilla and the mandible in the frontal region of the jaws. This suggests a compensatory mechanism for enlarged facial vertical dimensions with reduced labiolingual dimensions of the basal and alveolar bone in the frontal part of both jaws in such a way that normal or increased overbite can be present in subjects with long-face structure (see Fig. 1).

The objective of this study was to investigate the relations between the lower face height and the structure of the frontal alveolar process and the basal bone in the maxilla and in the mandible in persons with a normal overbite. The differences between groups of subjects with short-face, long-face, and average lower face height were investigated. A multiple stepwise regression analysis was performed to analyse the contribution of the structure of the alveolar process and the basal bone to the lower face height. Area measurements and proportions were developed to investigate the structure and size of the alveolar process and basal bone in the anterior region of both jaws.

We investigated (1) whether a longer lower face is associated with larger areas of the maxillary and mandibular frontal alveolar process and basal bone,

[a]Postgraduate student, Department of Orthodontics, ACTA, Amsterdam, The Netherlands.
[b]Assistant Professor, Department of Orthodontics, ACTA, Amsterdam, The Netherlands.
[c]Professor of Orthodontics, Department of Orthodontics, ACTA, Amsterdam, The Netherlands.
[d]Professor of Orthodontics, Department of Orthodontics, University of Hamburg, Germany.
[e]In private orthodontic practice, the Hague, The Netherlands.
[f]Professor of Oral Surgery, Department of Oral Surgery, Academic Hospital of the Vrije Universiteit, Amsterdam, The Netherlands.
Reprint requests to: Dr. R. B. Kuitert, Academic Centre of Dentistry Amsterdam, Department of Orthodontics, Louwesweg 1, 1066 EA Amsterdam NL.

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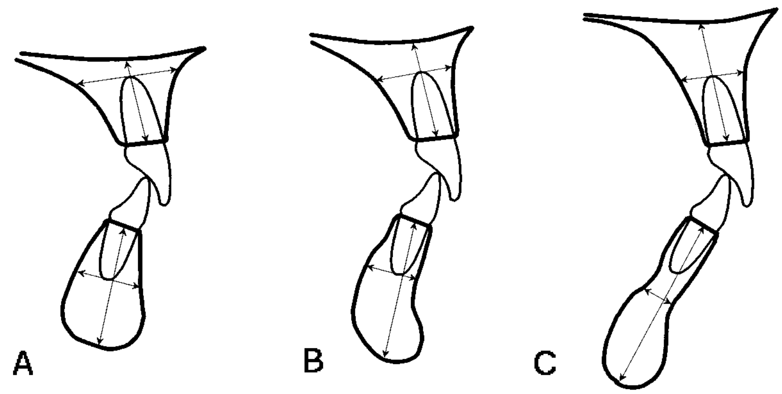

Fig. 1. A, Midsagittal projection of frontal alveolar and basal bone in subject with short lower face. Alveolar and basal depth is larger, whereas alveolar height is smaller; shortening of symphysis has taken place. **B,** Midsagittal projection of frontal alveolar and basal bone in case with normal lower face. Proportions between alveolar and basal depth and height are normal. **C,** Midsagittal projection of frontal alveolar and basal bone in subject with long lower face. Alveolar and basal depth is smaller, whereas alveolar height is larger; lengthening of symphysis has taken place.

whereas a shorter lower face is associated with smaller areas of the maxillary and mandibular frontal alveolar process and basal bone, and (2) whether a longer lower face is associated with a narrow and elongated shape of the maxillary and mandibular frontal alveolar process and basal bone, whereas a shorter lower face is associated with wider and shorter shapes of the maxillary and mandibular frontal alveolar process and basal bone (see Fig. 1, *A*, *B*, and *C*).

MATERIAL AND METHODS

Pretreatment cephalograms of 460 adults (191 males and 269 females) 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 in Amsterdam. The cephalograms were taken from subjects of white European origin. The female subjects were older than 17 years and the male subjects were older than 19 years. No subjects had severe craniofacial disorders, such as cleft palate, bridges, 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. Bilateral occlusal contact between at least one maxillary and one mandibular molar or premolar had to be present. This was identified by studying the written records, the intraoral slides, the plaster models, and also the cephalograms.

Out of the total sample of 460 subjects with overbites, ranging from –10 to +19 mm, 165 subjects with a normal positive overbite between 0.5 and 4 mm, as defined by Kim,[13] were selected. The overbite (OB) was measured in millimeters as the distance between the incisal edges of the maxillary and the mandibular central incisor perpendicular to the occlusal plane.

The cephalograms of all 460 subjects were traced. Twenty-two landmarks were identified and digitized. Four of these landmarks were constructed as support for measurements. A GTCO-digitizer (GTCO Corp.) connected to a 486DX-33 PC (Hewlett Packard) was used. Most landmarks were defined according to Riolo[15] and Steiner.[16] 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 12 measurements computed. The landmarks, reference lines, and measurements are described in Figs. 2 and 3.

The mean values and the standard deviations for the lower face height were calculated separately for male and female subjects with a normal overbite (N = 165). The results showed that, for the male group (N = 66), the mean lower face height was 74.42 mm and the standard deviation (SD) was 7.04. For the female group (N = 99), the mean lower face height was 68.29 mm and the SD was 7.13.

All subjects with a normal overbite were then subdivided into long-face, short-face, or control groups, according to the method of Ülgen.[19] The six groups were as follows:

A male short lower face group; the lower face height (LFH) being more than 1 SD below the mean

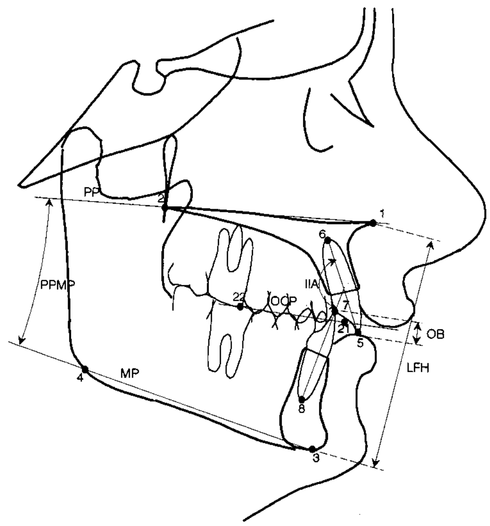

Fig. 2. Skeletal cephalometric landmarks, reference lines, and measurements used in study. Landmarks 1-8 are defined according to Riolo[15]: 1: Anterior nasal spine, tip of median sharp long process of maxilla at lower margin of anterior nasal opening; 2: posterior nasal spine, most posterior point at sagittal plane on bony hard palate; 3: menton, most inferior point on symphysial outline of chin; 4: 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; 5: incisal tip of central maxillary incisor; 6: apex of central maxillary incisor; 7: incisal tip of central mandibular incisor; 8: apex of central mandibular incisor; 21: frontal point of occlusal plane (midpoint between incisal ridges of maxillary and mandibular central incisors); 22: 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,[4] Schendel,[8] Prahl,[17] and Janson;[18] *PP*: Palatal plane, line connecting posterior and anterior nasal spine; *OCP*: Occlusal plane, line connecting points 21 and 22. Measurements: *LFH*: Lower face height, direct distance between Anterior Nasal Spine and Menton. *PPMP*: Palatomandibular angle, angle between palatal and mandibular plane; *OB*: Overbite, distance between incisal ridges of maxillary and mandibular central incisor perpendicular to occlusal plane. If there was no overlap between incisal ridges of maxillary and mandibular incisors, overbite was negative. IIA: Interincisal angle, angle between axes of maxillary and mandibular incisors.

(LFH being less than 67.4 mm), consisting of nine subjects.

A male control group with an average lower face height; the lower face height being within 1 SD of the mean (LFH being more than 67.4 mm and less than 81.5 mm), consisting of 47 subjects.

A male long lower face group; the lower face height being more than 1 SD above the mean (LFH more than 81.5 mm), consisting of 10 subjects.

A female short lower face group; the lower face height being more than 1 SD below the mean (LFH being less than 61.3 mm), consisting of 19 subjects.

A female control group with an average lower face height; the lower face height being within 1 SD of the mean (LFH being more than 61.3 mm and less than 75.5 mm), consisting of 64 subjects.

A female long lower face group; the lower face height being more than 1 SD above the mean (LFH being more than 75.5 mm), consisting of 16 subjects.

Overall differences among the groups were assessed by nonparametric Kruskall-Wallis H-tests. Intergroup differences between the groups of short-faced subjects, the groups of long-faced subjects, and the control groups were assessed by Mann-Whitney U tests. Correlations between the lower face height and all measurements were calculated for the total population ($N = 460$). To assess the relation between the lower face height and the shape and the area of the alveolar process and the basal bone, a multiple stepwise regression analysis was performed on the original population of 460 subjects, which also included open and deep bites. Other multiple stepwise regression analyses were performed on the original population of 460 subjects to determine the relative contribution of the shape and the area of the alveolar process and the basal bone to the variance of the alveolar and basal height. This regression analysis was performed separately for the maxilla and the mandible.

From 33 subjects, the tracing and digitizing process of the cephalogram was repeated by an independent observer. 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. Student's 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.

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

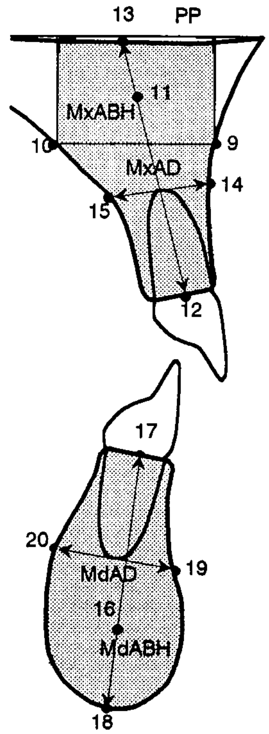

Fig. 3. Illustrations of dentoalveolar cephalometric landmarks, reference lines, and measurements used in study. Landmarks: 9: A-point, deepest point of curvature of frontal midsagittal section of maxilla (refer to Riolo[15]); 10: palatal counterpart of A point (2) on palatal cortical bone at same distance from palatal plane as A point; 11: center of rectangle limited by line 9-10 and palatal plane. Rectangle represents midsagittal section of basal bone of maxilla. This point was defined as center point of maxillary alveolus; 12: midpoint of alveolar meatus of maxillary central incisor; 13: 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); 14: frontal point of shortest line above apex of maxillary central incisors between maxillary midsagittal labial and palatal alveolar cortical bone; 15: dorsal point of shortest line above apex of maxillary central incisors between maxillary midsagittal labial and palatal alveolar cortical bone; 16: center point of basal midsagittal bone of mandible (point D according to Steiner[25]); 17: midpoint of alveolar meatus of mandibular central incisor; 18: 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); 19: frontal point of shortest line above apex of mandibular central incisors between mandibular midsagittal labial and lingual alveolar cortical bone; 20: 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, distance between points 14 and 15; *MdAD*: mandibular alveolar depth, distance between points 19 and 20. Maxillary alveolar index (MxAI) = MxAD/MxABH; mandibular alveolar index (MdAI) = MdAD/MdABH. 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 9-10. 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 short-face, control, and long-face subjects, female group multivariate tests (overall significance) performed with Kruskall-Wallis one-way ANOVA univariate tests performed with Mann-Whitney U-tests

	Short-face group female (N = 19)		*Control group female (N = 64)*		*Long-face group female (N = 16)*					
Variables	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Overall significance*	*Significance SF-CTR*	*Significance LF-CTR*	*Significance LF-SF*
MxABA	148.80	29.06	212.67	38.36	236.31	41.01	***	***	*	***
MdABA	272.34	30.45	313.68	45.13	333.87	53.05	***	***		***
LFH	56.66	2.71	69.49	3.70	77.29	1.44	***	***	***	***
PP-MP	17.26	4.72	27.80	5.53	33.93	5.51	***	***	***	***
Interincisal angle	129.60	14.03	128.59	10.16	132.16	8.60				
Overbite	2.59	1.14	2.46	0.91	1.51	0.58	***		***	**
MxABH	15.45	2.11	20.54	2.72	22.02	1.90	***	***	*	***
MxAD	13.01	2.25	11.65	2.85	10.57	1.95	**	*		***
MdABH	26.88	3.26	32.17	2.38	35.27	1.80	***	***	***	***
MdAD	9.74	2.03	7.85	1.82	7.02	1.88	***	***		***
MxAI	0.86	0.22	0.58	0.18	0.48	0.10	***	***	*	***
MdAI	0.37	0.09	0.25	0.07	0.20	0.05	***	***	**	***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
SF: Short-face group; *CTR:* control group; *LF:* long-face group.

Differences Among Female Subjects, Mann-Whitney U-tests

The differences among the female groups exceeded the differences found among the male groups but the general pattern of differences was gender independent. An overall difference was found for all variables except for the interincisal angle.

Larger lower face heights were associated with significantly larger areas of the maxillary and mandibular basal bone and the alveolar process and larger maxillary and mandibular alveolar and basal heights. All overall and intergroup differences were significant, except for the difference in the mandibular alveolar and basal area between the control group and the long-face group.

Groups with larger lower face heights had smaller maxillary, as well as mandibular alveolar depths, but the differences were larger for the mandibular depth, compared with the maxillary depths. For the mandibular alveolar depth, all intergroup differences were significant, whereas for the maxillary alveolar depth, the intergroup differences were significant only between the short-face and control groups, as well as between the short-face and long-face groups. The maxillary and mandibular alveolar indices were smaller in the group with larger lower face height; compared with groups with smaller lower face heights, the levels of significance were larger for the mandibular alveolar index. All overall and intergroup differences for the alveolar indices were significant.

Comparisons among the short-face group, the control group, and the long-face group showed that the long-faced subjects generally had larger palatomandibular angles, whereas the short-faced subjects had smaller palatomandibular angles. There was a small but significant difference between the long-face group and the other groups for the overbite, the overbite being smaller in the long-face group. The results are shown in Table I.

Differences Among Male Subjects, Mann-Whitney U-tests

Among the male groups, no significant differences were found for the interincisal angle, the overbite, the maxillary and the mandibular alveolar depth, and the maxillary alveolar index.

The pattern of intergroup differences regarding the palatomandibular angle, the maxillary and mandibular alveolar and basal areas, and the mandibular alveolar height were similar to the female groups. The maxillary alveolar height, however, was significantly smaller in the short-face group compared with the control group and the long-face group, but no significant difference was found between the control group and the long-face group.

The mandibular alveolar index was significantly larger in the short-face group and significantly smaller in the long-face group, compared with the control group. The results are shown in Table II.

Correlations With the Lower Face Height

The strongest correlation was found between the lower face height and the mandibular alveolar and basal height (0.82). The lower face height showed

Table II. Differences between short-face, control, and long-face subjects, male group multivariate tests (overall significance) performed with Kruskall-Wallis one-way ANOVA univariate tests performed with Mann-Whitney U-tests

Variables	*Short-face group male (N = 9)*		*Control group male (N = 47)*		*Long-face group male (N = 10)*		*Overall significance*	*Significance SF-CTR*	*Significance LF-CTR*	*Significance LF-SF*
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*				
MxABA	170.23	35.99	259.11	53.20	298.75	35.51	***	***	**	***
MdABA	306.85	44.76	371.34	59.54	392.83	66.86	**	**		**
LFH	61.39	3.88	74.93	3.75	83.71	2.30	***	***	***	***
PP-MP	15.56	4.12	26.60	6.10	34.20	7.24	***	***	**	***
Interincisal angle	133.06	12.50	130.74	9.97	129.77	10.11				
Overbite	2.66	0.99	2.11	1.04	1.86	0.89				
MxABH	16.00	1.59	21.26	3.06	22.92	2.81	***	***		***
MxAD	12.52	2.94	13.30	3.00	12.01	3.27				
MdABH	29.17	2.63	35.75	2.55	39.34	2.12	***	***	***	***
MdAD	8.50	1.61	7.79	1.91	6.60	1.95				*
MxAI	0.79	0.20	0.65	0.21	0.54	0.18				*
MdAI	0.30	0.07	0.22	0.06	0.17	0.05	***	**	*	**

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
SF: Short-face group; *CTR:* control group; *LF:* long-face group.

significant correlation coefficients above 0.6 with the palatomandibular angle, the maxillary and the mandibular alveolar and basal height, and the mandibular alveolar index. The results are shown in Table III.

Table III. Correlations between the lower face height and all variables used in the study

Variables	*R*
MxABA	0.57***
MdABA	0.37***
PP-MP	0.78***
Interincisal angle	−0.21***
Overbite	−0.56***
MxABH	0.70***
MxAD	−0.25***
MdABH	0.82***
MdAD	−0.48***
MxAI	−0.55***
MdAI	−0.69***

***$p < 0.001$.

Multiple Correlations With the Lower Face Height

According to the multiple stepwise regression analysis with LFH as dependent variable, 86% of the variance of the lower face height could be explained by a combination of the mandibular alveolar index, the maxillary alveolar and basal area, the overbite, the mandibular alveolar and basal area, and the maxillary alveolar index. A larger lower face height mainly coincided with a more narrowed and elongated shape of the symphysis, a larger maxillary alveolar and basal area, and a smaller overbite. The mandibular alveolar and basal area and the maxillary alveolar index were only of minor importance. The results are shown in Table IV.

Multiple Correlations With the Alveolar and Basal Height

According to the multiple stepwise regression analysis with the MxABH as dependent variable, 85% of the variance of the maxillary alveolar and basal height could be explained by a combination of the maxillary alveolar index and the maxillary alveolar and basal area. The results are shown in Table V. A larger maxillary alveolar and basal height mainly coincided with a larger maxillary alveolar and basal area and a more narrowed and elongated shape of the maxillary midsagittal frontal alveolar and basal bone.

According to the multiple stepwise regression analysis with the MdABH as dependent variable, 83% of the variance of the mandibular alveolar and basal height could be explained by a combination of the mandibular alveolar index and the mandibular alveolar and basal area. The results are shown in Table VI. A larger mandibular alveolar and basal height mainly coincided with a more narrowed and elongated shape of the symphysis and a larger mandibular alveolar and basal area.

DISCUSSION

In most articles concerning the long-face syndrome,[1,4,8,20-24] the long-face groups also include anterior open bite cases.[1,4,19] A study of Haskell[23] demonstrated that the bony chin in subjects with open bite was smaller, compared with a normal overbite group. This suggests a relationship between the overbite and the structure of the alveolar and

Table IV. Results of multiple linear regression analysis independent variable: lower face height

Variables	*R*	R^2	*SE*	*B*	β	*T*
MdAI	0.69	0.48	6.83	−49.92	−0.42	−18.81***
MxABA	0.81	0.66	5.54	0.04	0.27	11.00***
Overbite	0.89	0.80	4.25	−0.93	−0.42	−21.86***
MdABA	0.92	0.84	3.77	0.04	0.26	10.85***
MxAI	0.93	0.86	3.61	−5.95	−0.14	−6.58***
Constant				65.68		57.55***

***$p < 0.001$.
R, R^2, and SE display the values if the corresponding variables are added to the question.
B and β values are given for the total equation.

Table V. Results of multiple linear regression analysis independent variable: maxillary alveolar and basal height

Variables	*R*	R^2	*SE*	*B*	β	*T*
MxABA	0.73	0.53	2.50	0.60	0.60	31.96***
MxAI	0.92	0.85	1.42	−0.58	−0.58	−30.98***
Constant				65.68		50.28***

***$p < 0.001$.
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 VI. Results of multiple linear regression analysis independent variable: mandibular alveolar and basal height

Variables	*R*	R^2	*SE*	*B*	β	*T*
MdABH	0.67	0.45	3.11	0.04	0.62	32.47***
MdAI	0.91	0.83	1.71	−36.40	−0.69	−36.14***
Constant				28.30		59.18***

***$p < 0.001$.
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.

basal bone in the frontal part of the jaws. Therefore, in this study, only subjects with a normal overbite (between 0.5 and 4 mm) were selected for the intergroup comparisons. With this approach, the possible interaction between open bite and the long-face syndrome was eliminated. Only a few articles have dealt with subjects who, although showing a long face, had a normal overbite.[8,19] In these articles, the dentoalveolar height was measured but the structure, shape, and size of the alveolar and basal bone in the frontal part of the jaws, which was subject of this study, were not investigated.

In this study, more differences were found to be significant among the female groups than among the male groups. This is probably due to the smaller group sizes of the male subjects.

The results of this study indicate that a long-faced person generally will have a larger area of the maxillary alveolar and basal bone with no significant deviation of its shape. Although the cephalometric approach is only two-dimensional, this may indicate that the volume of the maxillary alveolar and basal area is larger. The larger volume of the maxillary alveolar and basal bone coincides with a longer maxillary alveolus. In the mandible, an even stronger relation between the symphysis and the lower face height is found. However, here the volume of the symphysis will not necessarily be larger. The vertical height of the symphysis is determined more by its shape than by its size. The increase in height of the symphysis seems to coincide more with a narrowing of its shape. Thus, in long-faced patients, the sagittal dimensions of the mandibular apical area in the incisor region is reduced in contrast to short-faced patients who have enlarged sagittal dimensions of the mandibular apical area. Consequently, the possibilities of labiolingual movement of the mandibular incisors in long-faced patients are limited. As the shape of the maxillary alveolar and basal bone is not related to the vertical facial dimensions, the scope of anteroposterior movements of the maxillary incisors is larger.

It should be noted that the regression analysis showed a relatively large standard error. However,

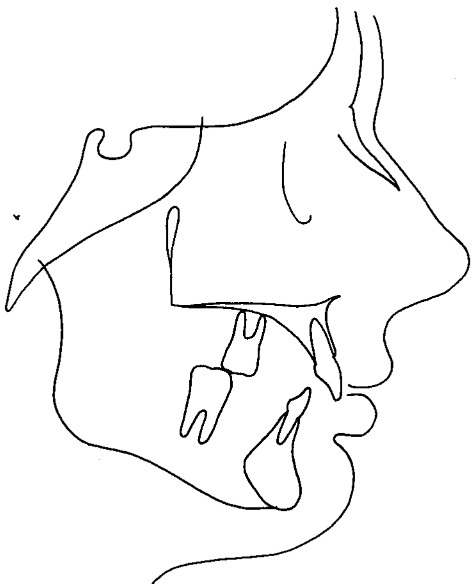

Fig. 4. Example of female patient from short-face group, age 18 years with small lower face height and normal overbite; LFH: 59.44 mm; PPMP: 24.30°; MxABA: 137.47 mm^2; MdABA: 271.54 mm^2; MxAI: 0.75; MdAI: 0.33; MxABH: 17.01 mm; MxAD: 12.81 mm; MdABH: 27.91 mm; MdAD: 9.14 mm; overbite: 2.41 mm; IIA: 137.95°.

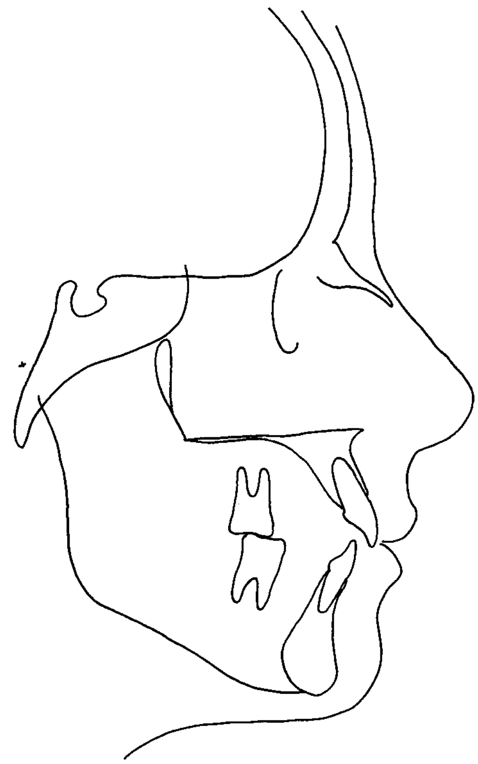

Fig. 5. Example of female patient from long-face group, age 39 years with large lower face height and normal overbite; LFH: 72.74 mm; PPMP: 29.21°; MxABA: 245.95 mm^2; MdABA: 323.94 mm^2; MxAI: 0.52; MdAI: 0.21; MxABH: 22.12 mm; MxAD: 11.43 mm; MdABH: 32.16 mm; MdAD: 6.90 mm; overbite: 1.69 mm; IIA: 135.29°.

the relations between the lower face height and the measurements used in this study are clear. Therefore we consider the results of the regression analysis a confirmation of the U tests, but it can be seen that a prediction of the lower face height based on the measurements used in this model will not be reliable enough. These results are illustrated by some examples of subjects from the long-face group and the short-face group in Figs. 4 and 5.

The fact that the palatomandibular angle was larger in the long-face group and smaller in the short-face group, whereas the overbite showed a difference only between the female long-face and female control groups indicates that a normal overbite is independent of the vertical divergence between the jaws. This is in agreement with the results of Fields,[4] Schendel,[8] and Ülgen.[19] In our study, the interincisal angle did not differ much among the three groups. Apparently, the interincisal angle is not related to the lower face height. This confirms the results of Ülgen,[19] who also found no significant differences between the long-face group and the control group for the interincisal angle.

Kraus et al.[25] studied the structure of separate bones of the facial skeleton in a sample of six sets of same-sex triplets. They investigated heredity as a determinating factor of the structure of the facial skeleton. Seventeen bone profiles whose shapes were inherited were identified, including the anterior and the posterior midsagittal contours of the frontal alveolar and basal bones in the maxilla and in the mandible. According to Kraus et al.,[25] the positions of the bones relative to each other could not be explained by heredity alone. He concluded that the environment plays a determinative role for the relative positions of the bones to each other, and consequently, for the structure of the facial skeleton as a whole. This may indicate that the shapes of the symphysis and the maxillary frontal alveolar and basal bone are determined by heredity, whereas the sizes of the symphysis and the maxillary frontal alveolar and basal bone are determined by the positions of the anterior and the posterior borders of these bone parts relative to each other. The relative positions of these bone parts are determined by other factors. Several investigators[25,26] concluded that the lower anterior face height is largely determined by heredity.[25-28] Because the lower anterior face height and the mandibular alveolar and basal shape seem to be related, it is possible that the shape of the frontal alveolar and basal bones is also at least partially influenced by the same genetic factors, which also determine the lower face height. As the maxillary alveolar and basal area also is correlated with the lower face height, the volume of the maxillary and basal bone might be influenced by the same genetic factor that controls the lower face height. This same factor also may influence the shape of the symphysis. However, as the volume of the symphysis is less strongly related to the lower face height, it may be controlled by a different factor.

The results of this study suggest that in long-faced patients, the mandibular midsagittal alveolar bone in the incisal region has limited anteroposterior dimensions. Therefore it seems advisable to exert some restraint in anteroposterior movements of these teeth in long-faced patients. This study does not provide any data with regard to the development of the lower face height. However, as indicated in the previous section, the shape of the symphysis and the lower face height may be determined by the same genetic factors. Therefore the shape of the symphysis may provide a clue for the prediction of the adult lower face height in growing subjects.

CONCLUSION

Long-faced patients with a normal overbite generally show a large alveolar and basal area of the maxilla with only slight deviations in its shape. The structure of the symphysis is more strongly related to the lower face height. However, with increasing lower face height, the symphysis is elongated and narrowed, whereas its area is only slightly increased. Thus, in growing subjects, the shape of the symphysis may be predictive for the adult lower face height.

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