Original Article

The Effects of Overbite on the Maxillary and Mandibular Morphology

İsmail Ceylan, DDS, PhD[a]; Ü. Barçın Eröz, DDS, PhD[b]

Abstract: The aim of this study was to investigate the differences in the maxillary and mandibular morphology related to the overbite. A total of 80 untreated subjects were divided into 4 groups with normal overbite, edge-to-edge bite, open bite, or deep bite and were compared with one another. Differences between the overbite groups and between genders were assessed by means of variance analysis and the least significant difference test. In addition, correlation coefficients between the overbite and other variables were calculated. The results showed that there are statistically significant differences in the maxillary and mandibular morphology among the overbite groups. (*Angle Orthod* 2001;71:110–115.)

Key Words: Overbite; Maxillary and mandibular morphology; Cephalometrics

INTRODUCTION

Consideration of facial type plays an important role in the formulation of an orthodontic treatment plan and prognosis of treatment. Of particular importance is the vertical relationship, ie, whether an individual is long faced or short faced. The vertical facial type provides a clue regarding the growth direction of the facial complex and should be used with an anteroposterior classification to describe a patient's face.[1]

The vertical development of the facial skeleton has been related to many skeletal units. The nasomaxillary complex, the alveolar processes, and the mandible have all been associated with normal and abnormal vertical development.[2–16]

A relationship may exist between the structures of the frontal part of the maxilla and the mandible and the lower face height such that, in cases with an open bite or a deep bite, the vertical dentoalveolar development may be inappropriate to compensate for the large or small distance between the jaws.[2] 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.[17,18] Several authors[19–22] reported significant differences between patients with normal and deep bite in the dentoalveolar region of the maxilla. Beckman et al[2] and Haskell[9] found that the size of the mandibular symphysis and chin were related to the overbite. These findings suggested that the overbite may be related to the morphological and dentoalveolar pattern of both jaws. Thus, the determination of this relationship may be useful in prediction of the treatment success in overbite problems.

Therefore, the purpose of this study was to investigate the relationship between the amount of overbite and the maxillary and mandibular morphology.

MATERIALS AND METHODS

The sample of 40 male and 40 female patient records was selected from approximately 3500 patient records present in the files of the Orthodontic Department at the Atatürk University dental facility. This study included pretreatment lateral cephalometric radiographs of all of the subjects, and all subjects were aged 13 to 15 years.

Selection of the subjects was based on following criteria:

1. no history of orthodontic treatment;
2. no severe craniofacial disorders, such as cleft palate;
3. no missing maxillary and mandibular first molar and anterior teeth.

The subjects were divided into 4 groups on the basis of the overbite. Overbite was measured as the distance between the incisal tips of the maxillary and mandibular central incisors perpendicular to the occlusal plane. Positive values for overbite indicated normal or deep bite, whereas open bite was indicated by negative values. In addition, each group was divided into 2 subgroups according to sex.

The 4 overbite groups were classified as follows:

1. open-bite group: overbite less than or equal to −1 mm,

[a] Associate Professor, Department of Orthodontics, Faculty of Dentistry, Atatürk University, Erzurum, Turkey.

[b] Research Assistant, Department of Orthodontics, Faculty of Dentistry, Atatürk University, Erzurum, Turkey.

Corresponding author: İsmail Ceylan, DDS, PhD, Atatürk Üniversitesi, Diş Hekimliği Fakültesi Ortodonti Anabilim Dalı, 25240-Erzurum, Turkey.
(e-mail: iceylan@atauni.edu.tr)

Accepted: August 2000. Submitted: June 2000.

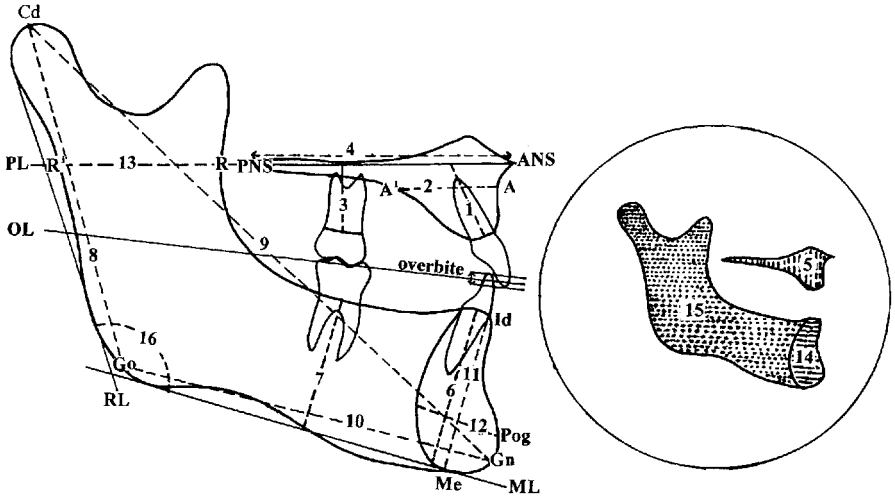

FIGURE 1. Cephalometric landmarks, reference lines, and measurements used in the study. (1) MxAABH. (2) MxAD. (3) MxPABH. (4) ANS-PNS. (5) MxA. (6) MdAABH. (7) MdPABH. (8) Cd-Go. (9) Cd-Gn. (10) Go-Gn. (11) SH. (12) SD. (13) RW. (14) SA. (15) TmdA. (16) Gonial angle.

2. edge-to-edge overbite group: overbite more than −1 mm but less than or equal to +1 mm,
3. normal-overbite group: overbite more than +1 mm but less than or equal to +4 mm,
4. deep-bite group: overbite more than +4 mm.

Twelve linear, 1 angular, and 3 area measurements were used to assess the maxillary and mandibular morphologies. The landmarks, reference lines, and measurements are described in Figure 1. The area measurements (maxillary area, symphyseal area, and total mandibular area) were made by means of an electronic planimeter, Ushikata X-plan 360-i (Ushikata Mfg Co, Tokyo, Japan). Each area was measured 3 successive times and the mean value of the 3 measurements was computed.

To determine the errors associated with radiographic measurements, 25 radiographs were selected at random from the observation group. The tracing and measurements were repeated 2 weeks after the first measurements, and no statistically significant difference was found between the 2 sets of measurements.

Differences between the overbite groups and between genders were assessed by means of a variance analysis. The least significant difference (LSD) test [23] was applied to the measurements at which F values were found to be statistically significant. In addition, correlation coefficients between the overbite and other variables were calculated. Means and standard deviations were computed for all measurements in each group.

Cephalometric measurements used in the study

Maxillary. Maxillary measurements used in the study are as follows (Figure 1):

1. Maxillary anterior alveolar and basal height (MxAABH, mm): The distance between the midpoint of the alveolar meatus of the maxillary central incisor and the intersection point between the palatal plane and the long axis of the maxillary central incisor.
2. Maxillary anterior depth (MxAD, mm): The distance between A and A′ points (A′: from point A, a line was drawn parallel to the nasal plane intersecting the dorsal contour of the maxillary alveolar bone).
3. Maxillary posterior alveolar and basal height (MxPABH, mm): The perpendicular distance between the midpoint of the alveolar meatus of the maxillary first molar and the palatal plane.
4. Anterior nasal spine-posterior nasal spine (ANS-PNS, mm): The distance between the maxillary ANS and PNS points.
5. Maxillary area (MxA, mm^2): The total area of the maxilla.

Mandibular. Mandibular measurements used in this study are as follows (Figure 1):

6. Mandibular anterior alveolar and basal height (MdAABH, mm): The distance between the midpoint of the alveolar meatus of the mandibular central incisor and the intersection point between the mandibular plane and the long axis of the mandibular central incisor.
7. Mandibular posterior alveolar and basal height (MdPABH, mm): The perpendicular distance between the midpoint of the alveolar meatus of the mandibular first molar and the mandibular plane.
8. Condylion-gonion (Cd-Go, mm): The distance between condylion and gonion points.
9. Condylion-gnathion (Cd-Gn, mm): The distance between condylion and gnathion points.
10. Gonion-gnathion (Go-Gn, mm): The distance between gonion and gnathion points.

TABLE 1. Means and Standard Deviations (SD) of Chronological Ages and Overbite Measurements for Each Group and *F* Values Found by Variance Analysis

Groups	Normal (n = 20)	Edge-to-Edge (n = 20)	Open Bite (n = 20)	Deep Bite (n = 20)	*F* Values
Chronological age (years)	13.35 ± 0.33	13.09 ± 0.33	14.20 ± 0.34	13.31 ± 0.33	2.05
Overbite measurement (mm)	3.13 ± 0.26	0.00 ± 0.26	−3.05 ± 0.27	5.90 ± 0.26	210.93***

*** $P < .001$.

11. Symphysis height (SH, mm): The distance between infradentale and menton points.
12. Symphysis depth (SD, mm): The distance between pogonion and the most posterior wall of the symphysis.
13. Ramus width (RW, mm): The distance between R and R′ points. (R and R′ points are anterior and posterior intersecting points of a posterior extension of the palatal plane on the mandibular ramus.)
14. Symphysis area (SA, mm²): The total area of the symphysis.
15. Total mandibular area (TmdA, mm²): The total area of the mandible.
16. Gonial angle: The angle formed at the gonial area between the posterior border of the ramus and a corpus line.

RESULTS

The means and standard deviations of the chronological ages and overbite measurements for each group and the *F* values are presented in Table 1. No statistically significant differences between the chronological age among the overbite groups were found. However, there were statistically significant differences in overbite measurements among the groups ($P < .001$).

The results of variance analysis are given in Table 2. According to these results, maxillary anterior and posterior alveolar and basal heights (MxAABH, MxPABH), ANS-PNS, maxillary area (MxA), mandibular anterior alveolar and basal height (MdAABH), symphysis height and depth (SH, SD), and gonial angle measurements showed statistically significant differences between the different overbite groups.

On the other hand, maxillary anterior and mandibular posterior alveolar and basal heights (MxAABH, MdPABH), Go-Gn, and symphysis area (SA) measurements demonstrated significant gender differences. In addition, Cd-Go and Go-Gn measurements showed significant interaction effects between gender and overbite groups.

The LSD test was applied to determine differences between overbite groups, and the results are presented in Table 3. According to these results, the most significant differences between overbite groups were concentrated between open-bite–deep-bite groups and open-bite–normal-overbite groups.

Correlation coefficients were calculated between the overbite and all measurements used in the study (Table 4). The largest correlations were found between the overbite and gonial angle (−0.738) and the maxillary posterior alveolar and basal height (MxPABH; +0.633) measurements. In addition, statistically significant correlations were found between the overbite and the maxillary anterior alveolar and basal height (MxAABH; 0.474), symphysis depth (SD; 0.455), mandibular anterior alveolar and basal height (MdAABH; −0.354), and symphysis height (SH; −0.337) measurements.

Descriptive statistics, including the means and standard deviations, were determined for each group and are shown in Table 5.

TABLE 2. The Results of Variance Analysis (see text for explanation of abbreviations)

Parameter		Overbite Group	Sex	Overbite × Sex
Maxillary				
1. MxAABH	(mm)	8.79***	4.55*	0.33
2. MxAD	(mm)	0.58	2.34	0.06
3. MxPABH	(mm)	19.02***	3.95	0.24
4. ANS-PNS	(mm)	4.52**	2.93	0.74
5. MxA	(mm²)	4.32**	2.61	0.20
Mandibular				
6. MdAABH	(mm)	3.44*	2.42	0.29
7. MdPABH	(mm)	2.46	6.94*	0.87
8. Cd-Go	(mm)	1.45	1.50	0.73
9. Cd-Gn	(mm)	1.93	3.59	3.08*
10. Go-Gn	(mm)	0.34	5.31*	2.93*
11. SH	(mm)	4.23**	0.27	0.29
12. SD	(mm)	7.03***	3.32	0.42
13. RW	(mm)	1.61	0.78	1.78
14. SA	(mm²)	1.35	6.52*	0.94
15. TMdA	(mm²)	1.92	3.95	2.67
16. Gonial angle		26.20***	0.68	2.75*

* $P < .05$; ** $P < .01$; *** $P < .001$.

DISCUSSION

Recently, a great emphasis has been placed on relationships between overbite and maxillary and mandibular dentoalveolar heights.[3,22,24–26] However, until now, relationships between overbite and overall maxillary and mandibular morphology have not been investigated in detail. In the present study, the relationships between overbite and both maxillary and mandibular morphology and dentoalveolar heights were investigated.

TABLE 3. The Results of LSD Test[a] (see text for explanation of abbreviations)

Parameter		Normal (1) ×	Edge-to-Edge (2) ×	Open Bite (3) ×	Deep Bite (4) ×	Significant Differences			
Maxillary									
1. MxAABH	(mm)	17.52 B	19.29 AB	21.03 A	17.63 B	1–3	—	—	3–4
2. MxPABH	(mm)	16.39 BC	17.96 B	21.14 A	15.05 C	1–3	2–3	2–4	3–4
3. ANS-PNS	(mm)	51.62 A	48.13 B	49.79 AB	51.47 A	1–2	—	2–4	—
4. MxA	(mm^2)	389.5 A	360.1 AB	353.8 AB	323.5 B	1–4	—	—	—
Mandibular									
6. MdAABH	(mm)	28.38 B	30.11 AB	30.92 A	28.18 B	1–3	—	—	3–4
11. SH	(mm)	28.38 AB	30.11 AB	31.48 A	26.72 B	—	—	—	3–4
12. SD	(mm)	15.17 A	14.15 A	11.82 B	14.95 A	1–3	2–3	—	3–4
16. Gonial angle		123.87 B	129.66 A	134.42 A	121.94 B	1–2	1–3	2–4	3–4

[a] There is no statistically significant difference between the measurements having the same letter, while the difference is statistically significant between the measurements with different letters ($P < .05$).

TABLE 4. Correlations Between the Overbite and All Variables Used in the Study (see text for explanation of abbreviations)

Parameter		Overbite *R*
Maxillary		
1. MxAABH	(mm)	0.474***
2. MxAD	(mm)	0.188
3. MxPABH	(mm)	0.633***
4. ANS-PNS	(mm)	0.263*
5. MxA	(mm^2)	−0.053
Mandibular		
6. MdAABH	(mm)	−0.354***
7. MdPABH	(mm)	−0.100
8. Cd-Go	(mm)	−0.075
9. Cd-Gn	(mm)	−0.219
10. Go-Gn	(mm)	−0.013
11. SH	(mm)	−0.337**
12. SD	(mm)	0.455***
13. RW	(mm)	0.189
14. SA	(mm^2)	−0.082
15. TMdA	(mm^2)	−0.080
16. Gonial angle		−0.738***

* $P < .05$; ** $P < .01$; *** $P < .001$.

The results of this study indicate that there are statistically significant differences in the maxillary and mandibular morphology and dentoalveolar heights among the overbite groups. Maxillary and mandibular dentoalveolar heights, symphysis height, and gonial angle in subjects with open bite were greater than in the other overbite groups, whereas subjects of the open-bite group generally had a smaller ANS-PNS length, maxillary area, and symphysis depth.

Haskell[9] 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. This may indicate that, in patients with open bite, the base of the symphysis may be narrowed. These results agree with our findings. In contrast, Beckmann et al[2] concluded that subjects with a deep bite generally showed a large area and narrowed shape of the symphysis. But there seems to be a conflict between the conclusions and the findings of that study. The results of our study showed that the shape of the symphysis in subjects with open bite was longer and narrower than in the other groups. In addition, the area of the symphysis in the open-bite group was greater than in the other groups, but the differences among the groups were not statistically significant. Fields et al[8] reported that the skeletal differences in long- and short-faced children were related to the mandibular morphology. They found that the length of the body and ramus of the mandible in long-faced and short-faced children was similar to that of normal children but the gonial angle greatly increased or decreased, respectively.

Schendel and coworkers[15] found a short ramus height in long-faced patients with open bite. Our data showed that the ramus height among the overbite groups was not statistically significant. Betzenberger et al[3] investigated skeletal and dentoalveolar changes in subjects with open bite and deep bite and found that there were statistically significant differences in anterior and posterior vertical facial heights and posterior maxillary and mandibular dentoalveolar heights between both groups. In our study, maxillary anterior and posterior dentoalveolar heights and mandibular anterior dentoalveolar height showed significant differences between the open-bite and deep-bite groups whereas mandibular posterior dentoalveolar height did not.

Beckmann et al[2] concluded that there are significant correlations between overbite and the measurements of maxillary and mandibular dentoalveolar heights, the size of the symphysis, and the maxillary and mandibular areas. Similarly, we found that the maxillary and mandibular dentoalveolar heights and the size of the symphysis were related to the overbite. However, the areas of the maxilla and mandible did not show significant correlation with the overbite.

TABLE 5. Means and Standard Deviations for all Variables Separately for Each Group (see text for explanation of abbreviations)

Parameter		Group			
		Normal	Edge-to-Edge	Open Bite	Deep Bite
Maxillary					
1. MxAABH	(mm)	17.52 ± 0.55	19.29 ± 0.55	21.03 ± 0.56	17.63 ± 0.55
2. MxAD	(mm)	15.40 ± 0.47	15.01 ± 0.47	15.00 ± 0.48	15.75 ± 0.47
3. MxPABH	(mm)	16.39 ± 0.59	17.96 ± 0.59	21.14 ± 0.60	15.05 ± 0.59
4. ANS-PNS	(mm)	51.62 ± 0.77	48.13 ± 0.77	49.79 ± 0.78	51.47 ± 0.77
5. MxA	(mm^2)	389.5 ± 13.0	360.1 ± 13.0	353.8 ± 13.2	323.5 ± 13.0
Mandibular					
6. MdAABH	(mm)	28.38 ± 0.71	30.11 ± 0.71	30.92 ± 0.72	28.18 ± 0.71
7. MdPABH	(mm)	22.84 ± 0.66	24.22 ± 0.66	22.26 ± 0.67	21.83 ± 0.66
8. Cd-Go	(mm)	54.74 ± 0.94	53.35 ± 0.94	55.77 ± 0.95	55.76 ± 0.94
9. Cd-Gn	(mm)	116.1 ± 1.50	113.8 ± 1.50	117.5 ± 1.53	112.87 ± 1.50
10. Go-Gn	(mm)	68.97 ± 1.15	67.38 ± 1.15	68.19 ± 1.17	68.58 ± 1.15
11. SH	(mm)	28.38 ± 0.99	30.11 ± 0.99	31.48 ± 1.01	26.72 ± 0.99
12. SD	(mm)	15.17 ± 0.57	14.15 ± 0.57	11.82 ± 0.57	14.93 ± 0.57
13. RW	(mm)	32.59 ± 0.73	30.54 ± 0.73	31.15 ± 0.74	32.10 ± 0.73
14. SA	(mm^2)	290.2 ± 9.16	275.3 ± 9.16	301.00 ± 9.30	284.8 ± 9.16
15. TMdA	(mm^2)	3027.5 ± 71.01	2839.8 ± 71.01	3044.3 ± 72.2	2901.3 ± 71.01
16. Gonial angle		123.9 ± 1.10	129.7 ± 1.10	134.4 ± 1.11	121.9 ± 1.10

The result of this study showed that subjects with open bite generally had increased maxillary and mandibular dentoalveolar heights, a larger gonial angle, and narrower and longer mandibular symphysis, whereas subjects with deep bite had the opposite characteristics. The shape of the symphysis and the measurements of dentoalveolar height and gonial angle may thus be used to assess the feasibility of overbite correction by orthodontic treatment.

CONCLUSIONS

This study demonstrated that maxillary and mandibular dentoalveolar heights and the size of the symphysis are affected by the overbite. Dentoalveolar heights were greater in the open-bite group than in the other groups. The subjects with open bite showed long and narrow symphysis, while the subjects with deep bite had a short and large symphysis form. The most significant change in mandibular morphology occurred in the gonial angle. The gonial angle was the largest in the open-bite group while smallest in the deep-bite group. The most pronounced morphological differences among the overbite groups were found between the open-bite and deep-bite groups and between open-bite and normal-overbite groups. In conclusion, it can be said that the evaluation of maxillary and mandibular dentoalveolar heights, the shape of the symphysis, and the gonial angle may be useful in the treatment success of overbite problems.

REFERENCES

1. Collett AR, West VC. Terminology of facial morphology in the vertical dimension. *Aust Dent J*. 1993;38:204–209.
2. Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, Tuinzing DB. Alveolar and skeletal dimensions associated with overbite. *Am J Orthod Dentofac Orthop*. 1998;113:443–452.
3. Betzenberger D, Ruf S, Pancherz H. The compensatory mechanism in high-angle malocclusions: a comparison of subjects in the mixed and permanent dentition. *Angle Orthod*. 1999;69:27–32.
4. Björk A. Prediction of the mandibular growth rotation. *Am J Orthod*. 1969;55:585–599.
5. Cangialosi TJ. Skeletal morphological features of anterior open bite. *Am J Orthod*. 1984;85:28–36.
6. Enlow DH, Harris DB. A study of the postnatal growth of the human mandible. *Am J Orthod*. 1964;50:25–50.
7. Feldmann I, Lundström F, Peck S. Occlusal changes from adolescence to adulthood in untreated patients with Class II division 1 deepbite malocclusion. *Angle Orthod*. 1999;69:33–38.
8. Fields HW, Proffit WR, Nixon WL, Phillips C, Stanek E. Facial pattern differences in long-faced children and adults. *Am J Orthod*. 1984;85:217–223.
9. Haskell BS. The human chin and its relationship to mandibular morphology. *Angle Orthod*. 1979;49:153–166.
10. Isaacson JR, Isaacson RJ, Speidel TM, Worms FW. Extreme variation in skeletal facial growth and associated variation in skeletal and dental relations. *Angle Orthod*. 1971;41:219–229.
11. Isaacson RJ, Zapfel RJ, Worms FW, Bevis RR, Speidel TM. Some effects of mandibular growth on the dental occlusion and profile. *Angle Orthod*. 1977;47:97–106.
12. Janson GRP, Metaxas A, Woodside DG. Variation in maxillary and mandibular molar and incisor vertical dimension in 12-year-old subjects with excess, normal, and short lower anterior face height. *Am J Orthod Dentofac Orthop*. 1994;106:409–418.
13. Opdebeeck H, Bell WH. The short face syndrome. *Am J Orthod*. 1978;73:499–511.
14. Opdebeeck H, Bell WH, Eisenfeld J, Mishelevich D. Comparative study between the SFS and LFS rotation as a possible morphogenic mechanism. *Am J Orthod*. 1978;74:509–521.
15. Schendel SA, Eisenfeld J, Bell WH, Epker BN, Mishelevich DJ. The long face syndrome: vertical maxillary excess. *Am J Orthod*. 1976;70:398–408.

16. Schudy FF. The rotation of the mandible resulting from growth. Its implications in orthodontic treatment. *Angle Orthod*. 1965;35: 36–50.
17. Harzer W, Reinhardt A, Soltes K. Der offene Biss. Morphologie und therapeutische Konsequenzen. *Zahn Mund Kieferheilkd*. 1989;77:421–426.
18. Stöckli P. Fernröntgenologische Aspekte bei der Beurteilung des offenen Bisses. *Schweiz Monatsschr Zahnheilkd*. 1966;76:359–368.
19. Ellis E, McNamara JA. Components of adult Class III malocclusion. *Am J Orthod*. 1984;86:277–290.
20. Frost DE, Fonesca RJ, Turvey TA, Hall DJ. Cephalometric diagnosis of apertognatia. *Am J Orthod*. 1980;78:657–669.
21. Lopez-Gavito G, Wallen TR, Little RM, Joondeph DR. Anterior open bite malocclusion, a longitudinal 10-year postretention evaluation of orthodontically treated patients. *Am J Orthod*. 1985;87: 175–186.
22. Subtelny JD, Sakuda M. Open-bite: diagnosis and treatment. *Am J Orthod*. 1964;50:337–358.
23. Keppel G. *Design and Analysis: A Researchers Handbook*. Englewood Cliffs, N.J.: Prentice-Hall; 1973:596.
24. Atherton JD. The influence of the face height upon the incisor occlusion and lip posture. *Dent Pract Dent Rec*. 1965;15:227–231.
25. Richardson A. Dento-alveolar factors in anterior open-bite and deep overbite. *Dent Pract Dent Rec*. 1970;21:53–57.
26. Nahoum HI, Horowitz SL, Benedicto E. Varieties of anterior open bite. *Am J Orthod*. 1972;61:486–492.