An Investigation Of The Vertical Overbite During The Eruption Of The Permanent Dentition

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The general process of the development of occlusion has received considerable attention dating back to our earliest recorded dental knowledge. Some aspects of occlusal development have been investigated in detail, but the problem of the vertical overbite is relatively less studied. In order to increase our understanding of this subject, the following study of the vertical overbite was designed.

REVIEW OF THE LITERATURE

The vertical overbite has been defined by Strang[1] as, "the overlapping of the upper incisors over the lowers in a vertical plane."

To-day, we consider a moderate degree of overbite to be a normal characteristic. Neff[2] expressed overbite as a percentage of the lower incisor covered by the corresponding upper incisor. Further, he considered a twenty per cent overbite as ideal.

On the other hand, an excessive degree of overbite has been said to contribute to the etiology of a variety of conditions affecting the masticatory apparatus. These conditions include relapse following orthodontic treatment[3], interference with the normal closure pattern of the mandible[4], periodontal disease[5] and malfunction of the temporomandibular joint[6].

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With regard to the factors influencing the extent of the overbite itself, an infinite variety of clinical opinions and research findings have been reported in the literature. Among the most important factors are:

1. *Cusp Height.*

It has been stated by Bonwell[7] in connection with his work on artificial teeth, "that the overbite in the incisor region is governed by the depths of the cusps of the molars and premolars, which vary in different individuals." This was corroborated by Popovich[8], who, studying the natural dentition, found a strong positive correlation existing between cusp height and the degree of the vertical overbite in cases of normal occlusion.

2. *Ramus Length.*

Diamond[9] wrote, "the primary factor in increasing the vertical development of dental height is the growth in length of the ramus." He indicated that retardation of ramus length growth inhibited the eruption of the posterior teeth but did not interfere with the eruption of the anterior teeth, thus resulting in an excessive degree of overbite. In testing this hypothesis, Wylie[10] compared the ramus length in cases of slight (1.5 - 2.0 mm) overbite with that found in cases of severe overbite, and failed to find any significant difference between the two. Later, Popovich[8] found that there was a significant negative correlation between ramus length and overbite in his group of Class

II deep overbite cases but this relationship was not found in the Class I group.

3. *Molar Height.*

This term has been used to indicate the degree of eruption of the posterior teeth. Following Diamond's reasoning, one might expect to find a difference in molar height between normal and severe overbite groups. Indeed, this was Wylie's[10] finding. Prakash and Margolis[11] found a strong negative correlation between lower molar height and the depth of the overbite, while Popovich[8] found such a relationship existing for the upper molar height in Class II cases only. He found no correlation whatsoever between lower molar height and the degree of the overbite.

4. *The Interincisal Angle.*

The relationship of this factor to the degree of the overbite was described by Steadman[12], who reported that the degree of the overbite was dependent upon the degree of angulation of the incisor teeth. It was shown that the overbite decreased as the interincisal angle decreased below 180 degrees, and increased at an even more rapid rate as this angle exceeded 180 degrees. Popovich[8] confirmed this finding by showing that significant positive correlations exist between the interincisal angle and the degree of the vertical overbite in deep overbite cases (Angle Classes I and II). In Popovich's[8] Class I cases with a normal degree of overbite, this relationship was not evident.

5. *Incisor Dimensions.*

Neff[2] has reported that the degree of overbite is related to the harmony, or lack of it, existing between the mesiodistal dimensions of the upper and lower incisor teeth. Neither Bauerle[13] nor Bolton[14] was able to confirm this observation using Neff's "anterior coefficient," and both agreed that a "significant correlation could not be found when the degree of overbite was related to tooth size, via the anterior ratio."

Studies of a longitudinal nature on the subject of the vertical overbite have been infrequent. One such study employing serial record casts was carried out by Barrow and White[15] who reported that the mean overbite decreased slightly between the ages of four and five years, increased by 1.75 mm. by eleven years, and remained relatively unchanged thereafter. After examining lateral cephalometric films of a group of Swedish boys observed at twelve years and again at twenty years, Bjork[16 17] reported an average reduction in the vertical overbite of 0.65 mm. during the period twelve to twenty years. More recently, in a study carried out on serial record casts, Bauerle[13] states, "it will be seen that, typically, the overbite increases from 1.75 mm. at the deciduous age, reaches a maximum of 3.8 mm. at age twelve, and then decreases to 3.4 mm. at age fifteen." Bauerle[13] found no significant sex differences at any age, no significant correlation between the degree of overbite in the late deciduous dentition and that at age fourteen and one-half, and no relationship between the overbite at age nine and that at age fourteen and one-half. These findings would appear to be in contradiction to the statement by Barrow and White[15] that the overbite remains relatively stable after eleven years, since Bauerle[13] found the reduction between twelve and fifteen years to be significant.

Method and Material

This study consists of two parts: 1) the study of record casts and 2) the study of lateral cephalometric films.

Long series record casts from the University of Michigan Elementary and High Schools Growth Study were select-

ed. These casts covered the age period from nine to sixteen years inclusive. the impressions being taken as nearly as possible to the subject's birthdate. The casts were selected according to the following criteria:

1. All subjects must show contact between upper and lower incisor teeth.

2. Only subjects having Class I (Angle) molar relationship were considered.

3. All subjects must be orthodontically untreated.

4. There must be no congenitally missing teeth, nor space loss due to caries.

5. There must be no severe rotations.

6. There must be no spacing nor crowding estimated to be greater than two mm in each arch.

In order to increase the sample size, additional casts were examined on a cross-sectional basis and the data added to the serial material. In addition, the data compiled by Bauerle[13] were tested against the data from the present study and, since there was found to be no statistically significant difference between the two samples at any age, the data were combined.

Before measurement, the casts were examined and all the artifacts which might interfere with the occlusion removed. They were then oriented in centric occlusion (See Fig. 1). A plane of occlusion was estimated by sighting a line from the tip of the maxillary central incisor to the tip of the mesiobuccal cusp of the first permanent molar of the same quadrant. A fine pencil mark, in line with the plane of occlusion, was then scribed on the labial surface of the lower central incisor. The distance from this point to the incisal edge of the lower central incisor was then measured to the nearest tenth of a millimeter using a fine pointed vernier caliper. This measurement was

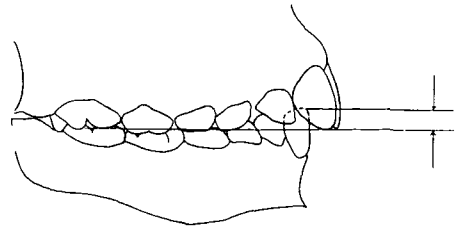


Fig. 1

then recorded as the overbite for the individual at the appropriate age.

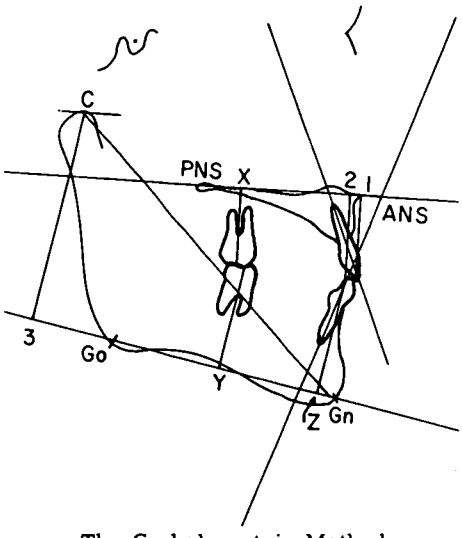
From these measurements, means were computed for both sexes at all ages, nine through sixteen years, and tests of significance ('t' tests) were carried out in order to compare the two sexes. Lateral cephalometric films of the same individuals included in Bauerle's[13] cast study were obtained. To these data were added a group of similar films from the files of the University of Michigan Elementary and High Schools Growth Study. All cephalograms were taken with the teeth in occlusion, approximating the birthdate of the individual. All subjects included in this part of the study were required to meet the same criteria used in the selection of the record cast.

Tracings were made of these films and measurements were made from the tracings using a fine pointed vernier caliper. The following points of reference (See Fig. 2) were used:

1. Anterior nasal spine, ANS.

2. Posterior nasal spine, PNS.

3. ANS - PNS plane. This plane was chosen as the basic plane of reference for the majority of the measurements. Since it has been shown by Brodie[18] that this plane "descends from the cranial base in such a manner that its successive stages are parallel to one another," and since this plane is situated in close proximity to the area being studied, it is well suited to the purpose of this study.



The Cephalometric Method.

Fig. 2

4. Crown tip of the maxillary central incisor, $\underline{1}$.

5. Crown tip of the mandibular central incisor, $\overline{1}$.

6. Midpoint of the occlusal surface of the upper first permanent molar, $\underline{6}$.

7. Midpoint of the occlusal surface of the lower first permanent molar, $\overline{6}$.

8. Mandibular plane (Go - Gn).

9. Condylion, C.

Using these points of reference, the following measurements were made (Fig. 2):

1. Anterior alveolar height (upper), the length of a perpendicular erected from the ANS - PNS plane to the crown tip of the maxillary central incisor, $(1 - \underline{1})$.

2. The length of a perpendicular erected from the ANS - PNS plane to the crown tip of the lower central incisor, $(2 - \overline{1})$.

Having these two measurements, the extent of the overbite for this age can now be calculated by subtracting the latter measurement from the former.

3. Ramus length, the length of a perpendicular erected from the mandibular plane to condylion, (C - 3).

4. Anterior alveolar height (lower), the length of a perpendicular from the mandibular plane to the crown tip of the lower central incisor, $(Z - \overline{1})$.

5. The angle of the upper central incisor to the ANS - PNS plane.

6. The angle of the lower central incisor to the mandibular plane.

7. The interincisal angle.

8. Posterior alveolar height (upper), the length of a perpendicular erected from the ANS - PNS plane to the midpoint of the occlusal surface of the upper first permanent molar, $(X - \underline{6})$.

9. Posterior alveolar height (lower), the length of a perpendicular erected from the mandibular plane to the midpoint of the occlusal surface of the mandibular first permanent molar, $(Y - \overline{6})$.

10. Mandibular length, (C - Gn).

After tabulating the values for the eleven variables including overbite at all ages, nine to seventeen inclusive, the data were prepared for processing on the I. B. M. 704 Computor. Means, standard deviations and correlations for various groups and combinations of groups were thus obtained. Statistical procedures applied to the material produced by the computor consisted of Z score transformations to test the significance of the correlations, and 't' tests to check for significant differences between the means of the various measurements.

Findings

1. *The study of record casts.*

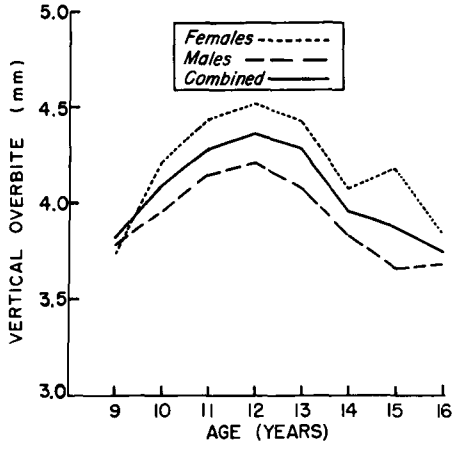
A. *Variation in the vertical overbite with age.*

Table 1
The Vertical Overbite Age 9-16 Years

Age	Mean(mm)	S.D	Range	N
9	3.81	1.063	1.2-5.6	58
10	4.10	0.992	1.3-6.5	79
11	4.29	0.977	1.7-7.2	78
12	4.37	0.876	2.2-7.2	74
13	4.29	0.907	2.3-7.5	69
14	3.97	1.018	2.3-7.8	65
15	3.88	0.947	1.9-7.3	54
16	3.75	1.149	1.9-7.3	48

Table 1 illustrates the extent of the vertical overbite for each age, nine through sixteen years. Testing revealed no statistically significant difference between males and females at any of these ages, therefore, the combined data are listed.

From these data it will be seen that the mean overbite for the sample increases in extent from 3.81 mm at age nine years to reach a maximum of 4.37 mm at age twelve years. Following this, there is a gradual decrease to 3.75 mm at age sixteen. Tests of significance indicate the 0.56 mm increase between the ages nine and twelve years and the 0.62 mm decrease between twelve and sixteen years to be highly significant (P=.001). These findings therefore substantiate those reported by Bauerle[13].



Variation in the vertical overbite (Cast Study).

Fig. 3

Figure 3 is a graphic presentation of the data in Table 1. It can be seen that the greatest incremental increase in the overbite (0.29) mm) occurs between the ages of nine and ten years, and the greatest decrease (0.32 mm) between the ages of thirteen and fourteen years. Although the difference between the mean overbite of males and females is not statistically significant, the mean for females tends to be greater than that for males except at age nine. The mean time at which the peak of the overbite occurs is the same in both sexes.

B. *Individual Variation.*

Although Figure 3 is representative of the sample as a whole, a considerable degree of individual variation is noted within the group. This individual variation is indicated by the wide range of the overbite measurement at all ages. The standard deviation being near 1.0 mm at each age indicates little change in variability with age.

The variability amongst individuals was evidenced by the range and standard deviation at each age. Further, although the great majority of individuals in the serial data showed curves similar to that illustrated in Figure 3, others showed either increase to a peak and no reduction, or a steady increase throughout the length of the observations, while a few exhibited no definite pattern. Of those individuals who followed the typical pattern, there was considerable variation with respect to the age at which the peak of the overbite was reached (ten - fourteen years). This agrees with Bauerle's findings.

II. *The Study of Lateral Cephalometric Films.*

A. *Variation in the vertical overbite with age.*

Table II

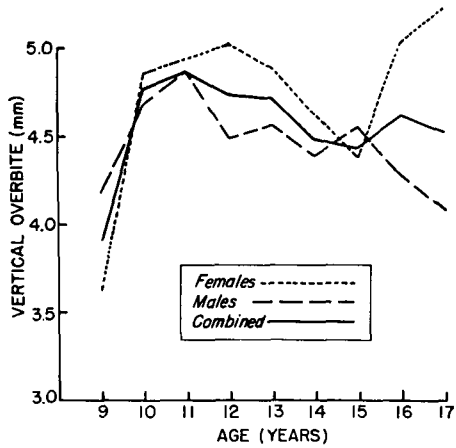
The Vertical Overbite Age 9-17 Years

Age	Mean (mm)	S.D	Range	N
9	3.91	0.736	2.3-4.9	12
10	4.77	0.849	2.4-6.0	25
11	4.87	1.040	2.1-7.0	24
12	4.74	1.023	2.3-6.8	28
13	4.72	0.966	2.4-6.5	24
14	4.48	1.311	1.7-7.4	30
15	4.43	1.040	1.6-6.5	26
16	4.62	1.120	2.3-7.0	20
17	4.52	1.154	2.6-6.7	16

Table 2 illustrates the extent of the vertical overbite for each age, nine through seventeen years. Testing revealed no statistically significant difference betweeen males and females at any of these ages, nor between the Michigan and Iowa samples, therefore the combined data are listed.

From these data it will be seen that the mean overbite for the sample increases in extent from 3.91 mm at age nine years to reach a maximum of 4.87 mm at eleven years. Following this, there is a decrease to 4.43 mm at age fifteen. It is therefore possible to demonstrate, by means of a cephalometric analysis, the same pattern of variation in the vertical overbite which had previously been demonstrated on casts.

In the data presented in Table 2, certain discrepancies are seen when compared with Table 1 (the cast study data). The age at which the peak of the overbite occurs is eleven rather than twelve. There is an apparent rise in the overbite between fifteen and sixteen years and then a reduction at seventeen years. These fluctuations are probably due to the small sample size and the wide range of the individual overbite measurements. It is interesting to note that when the serial data only is considered, the peak of the overbite is at twelve years of age.



Variation in the vertical overbite (Cephalometric Study)

Fig. 4

Figure 4 is a graphic presentation of the data in Table 2. It can be seen that, although the difference between the mean overbite of males and females is not statistically significant, the mean values for females tend to appear slightly greater than those for males except at age nine years. This is agreement with the findings of the cast study. The greatest incremental increase (0.86 mm) for the combined sample occurs between the ages of nine and ten years, and the greatest decrease (0.24 mm) between the ages of thirteen and fourteen. This also is in agreement with the findings of the cast study.

B. *The association of certain craniofacial dimensions with overbite.*

In order to determine which, if any, of the measurements described in the section on method and material were possibly associated with the degree of overbite, correlation coefficients were calculated for each measurement with the degree of overbite. These data are presented in Table 3.

It was found that for each sex there are five of these measurements whose means show statistically significant cor-

Table III
Correlation of Certain Craniofacial Dimensions with Overbite

	Craniofacial Dimension	r	P
M	$\overline{1}$ to ANS - PNS plane	—.237	.02
A	Ramus length	—.372	.01
L	Posterior alveolar height (upper)	—.218	.02
E	Posterior alveolar height (lower)	—.238	.02
S	Mandibular length (C-Gn)	—.239	.02
F			
E	$\overline{1}$ to ANS - PNS plane	—.241	.02
M	Ramus length	—.241	.02
A	$\underline{1}$ to ANS - PNS plane	+.253	.02
L	Anterior alveolar height (lower)	+.429	.01
E	Angle $\overline{1}$ to Go-Gn	—.531	.01
S			
C	$\overline{1}$ to ANS - PNS plane	—.279	.01
O	Ramus length	—.239	.02
M	Anterior alveolar height (lower)	+.208	.05
B	Angle $\overline{1}$ to Go-Gn	—.200	.05

relation with the degree of overbite. Two of these measurements (ramus length, and the distance from the tip of the lower incisor to the ANS - PNS plane) are significant in both sexes, while three measurements are significant only within the one sex.

When the sample was combined without regard to sex, only four measurements show statistically significant correlations with the overbite.

Discussion

This study substantiates the work of Bauerle[13] in showing that there is a variation in the extent of the vertical overbite with age and that, typically, this variation can be represented by a curve with its peak at twelve years of age. The finding of a reduction in the extent of the overbite following twelve years of age is also in agreement with the reduction between twelve and twenty reported by Bjork.[16 17] Since, normally, the teeth of females erupt at an earlier age than do the same teeth in males, it is difficult to explain the finding in the cephalometric study that the overbite is deeper in boys than in girls at age nine years. This peculiarity is probably the result of the relatively smaller sample at this age.

Certain craniofacial dimensions have been shown to hold a statistically significant relationship to the degree of vertical overbite:

1. The anterior alveolar height (upper), which is a measure of the distance from the tip of the maxillary central incisor to the palatal plane (ANS-PNS), was found to hold a significant positive ($p<.02$) correlation with the degree of overbite in females only. When the samples were combined, the relationship no longer was significant.

2. The distance from the tip of the lower central incisor to the palatal plane was found to hold a significant negative relationship to the degree of overbite. This would seem to be an obvious finding in view of the method used in determining the degree of overbite. This

relationship is significant ($P<.02$) in both males and females and in the combined sample ($P>.01$).

3. The anterior alveolar height (lower) was found to have a highly significant positive ($P<.01$) relationship to the degree of overbite in females only. When the two sexes were combined, this relationship was reduced greatly in significance ($P<.05$). This dimension also holds highly significant positive relationships with the anterior alveolar height (upper), and the posterior alveolar height (upper and lower).

4. The length of the ramus of the mandible was found to hold a significant negative relationship to the degree of overbite in both males and females, with the relationship being stronger in males ($P<.01$) than in females ($P=.01$). When the sample was combined, this factor was still significant ($P<.02$). This is in contrast to the findings of Popovich[8] who failed to find any significant relationship between ramus length and the degree of overbite in his Class I groups, but who found such a relationship to exist in his Class II group. This finding would tend to support the work of Diamond[9] who indicated that retardation in ramus length growth was associated with the formation of deep overbite.

5. Posterior alveolar heights (both upper and lower) were found to hold significant negative relationships ($P=.02$) to the degree of overbite in males only. When the male and female samples were combined, these relationships no longer reached a significant level. This finding would tend, with regard to the male sample, to support the findings of Prakash and Margolis[11] who showed that the overbite was related to the lack of upper and lower molar height. The obvious differences in findings between this study and that of Popovich[8], with respect to this dimension, may possibly be due to the fact that in Popovich's data, males and females were combined. In this study, they were treated separately as well, with the result that certain sex differences became apparent.

6. Mandibular length (C-Gn) was found to hold a significant negative relationship to the degree of overbite in males only ($P<.02$). This relationship was not significant when the samples were combined.

7. The angle of the lower incisor to the mandibular plane (Go-Gn) was found to hold a highly significant negative relationship ($P<.01$) to the overbite in the female sample only. When the two samples were combined this relationship, although still negative, was reduced in significance. ($P<.05$).

The greatest reduction in the degree of the vertical overbite comes between thirteen and fifteen years of age. On examining the data for the various craniofacial dimensions, it was found that this was also the period of greatest incremental growth in the ramus of the mandible, also that this increment of growth is much more marked in males than in females. In this respect, the findings are in agreement with those reported by Nanda.[19] If the reduction in overbite after twelve years of age were due to the growth "spurt" in the length of the ramus, one might expect to find greater reduction in overbite in males than in females since the incremental growth in ramus length in males is much greater (males 6.76 mm or 12.4%, females 3.87 mm or 7.6% between thirteen and fifteen years). Using the figures of the cast study since the sample is larger, it was found that this was not the case — the reduction was 0.67 mm in females and 0.52 mm in males. When calculated as a percentage of the greatest overbite (age twelve years), this reduction in females

is 14.8% and in males 12.4%.

By graphing the movement of the tips of the upper and lower incisors in relation to the palatal plane, it was found that the lower incisor between the ages of thirteen and fifteen "grows away" from the palatal plane at a more rapid rate than does the upper incisor. This is another indication that the reduction in overbite after twelve years of age is at least partly due to a rate of growth which is greater in the mandible. Since during this period the mandibular growth rate is greater in males than in females, one would expect to find that the distance between the lower incisor and the platal plane increases proportionately more rapidly in males than in females. The data on this dimension shows this to be true since in the males the increase is 2.46 mm (10.4%), while in females it is only 1.41 mm (5.8%).

Pursuing this line of thought still further, if the distance from the lower central incisor to the palatal plane increases to a proportionately greater degree in males than in females, the degree of overbite should decrease to a greater extent in males than in females. It has already been shown that this is not the case. Examination of the data revealed that the distance between the upper incisor and the palatal plane also was increasing proportionately more rapidly in males than in females. Increase in this dimension in males between thirteen and fifteen years was 1.44 mm (4.7%), while the increase in females was 0.90 mm (3.1%).

One might therefore postulate that the reduction in the degree of overbite after twelve years of age is brought about by growth in the length of the ramus which carries the mandible away from the remainder of the craniofacial complex. The great difference in the rate of ramus length growth in males as compared with females is prevented from "showing up" in the reduction of the overbite by virtue of a compensatory increase in the eruption of the upper incisor in males.

From a clinical point of view it might therefore be reasoned that efforts to reduce the degree of overbite would be least successful in the period before twelve years of age and most successful after this time, particularly during the period thirteen to fifteen years. In assessing the clinical application of this study, however, it must be kept in mind that the actual amount of increase and decrease in the degree of overbite is extremely small and probably of little clinical significance except for its relation to the general pattern of growth.

Summary

A study of the vertical overbite during the period nine to seventeen years was carried out using orthodontic casts and lateral cephalometric films. It was demonstrated that the mean overbite increases from age nine to twelve years and then decreases to the end of the period of observation. There is no statistically significant difference in the degree of overbite in males and females, although the means for females tend to run slightly higher.

The degree of the vertical overbite was shown to be associated with a number of craniofacial dimensions of which ramus length is possibly the most important.

Conclusions

On the basis of this study, it may be concluded that in subjects with Class I (Angle) molar relations:

1. There is a definite cycle to the degree of the vertical overbite which increases from nine to twelve years of age and thereafter decreases, at least to age seventeen.

2. The overbite is related to a num-

ber of craniofacial dimensions, some of which are of importance in both males and females, while others are of importance only in the case of males or females as the case may be.

3. There is some evidence to indicate that the reduction in the overbite following twelve years of age may be due to growth of the ramus of the mandible.

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