Longitudinal relationship between incisal occlusion and incisal tooth wear

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The purpose of the study was to evaluate the longitudinal relationship between incisal wear of central incisors and the size of vertical overbite (OB) and horizontal overjet (OJ). Stone casts of 51 subjects were used for the determinations. Casts were obtained when the subjects were 15 and 27 years old. Statistical analysis was performed with the *t* test for paired samples, the chi-square test of association, Pearson's product moment correlation coefficient, and Spearman's rank correlation coefficient. Both overbite and overjet diminished after 12 years, and incisal wear increased. It was concluded that increase in age, incisal wear, vertical overbite and incisal occlusion (OB/OJ) are clinical predictors of wear of maxillary and mandibular central incisors in adolescents. □ *Attrition; incisal occlusion; incisal wear*

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Regular wear of natural teeth is a physiologic process, but many factors may affect the type and rate of wear (1). Most studies on tooth wear have been cross-sectional, and longitudinal investigations are exceptional. Carlsson et al. (2) examined 18 patients with moderate to severe wear and re-examined them after 6–10 years. The mean age at the first examination was 42 years for men and 34 for women. They assessed original wear on casts and intraoral photographs taken at the first examination in accordance with a 5-grade scale. Continuation of wear was assessed with a 4-grade scale by comparing and measuring casts from the first and the second examination. A questionnaire was used, and bite force measurements taken. In addition, dietary and salivary analyses were carried out. They concluded that parafunctions (clenching and grinding) together with several other variables may contribute to dental wear, which itself is a slow process. The results of another longitudinal study were presented by Nyström et al. (3). They examined 42 subjects who had dental casts of both jaws made at the approximate age of 5, 10, 14, and 18 years. They assessed wear by measuring the area of the wear facets of the anterior maxillary teeth by planimetric methods. They used questionnaires concerning parafunctions, made dietary and salivary analyses, and measured bite force. Cephalometric radiographs were applied to measure variables for possible association with dental wear. They concluded that anterior dental wear increased with age and that dental wear was correlated with anterior bite force but not with parafunctions. Further, the results of the cephalometric measurements showed a low negative but statistically significant correlation between anterior dental wear and the size of the gonial angle. The results of the measurements of horizontal overjet and vertical overbite showed that the only significant correlation between overjet and dental wear was encountered at the age of 14 years. All correlations between the size of the vertical overbite and the size of the wear facets were close to zero.

The purpose of the present work was to study the longitudinal development of the size of the vertical overbite and horizontal overjet and to relate these events to the longitudinal progress of incisal wear of central maxillary and mandibular incisors.

Materials and methods

The participants in the study group were 51 individuals (23 women, 28 men) who had received regular dental care by one of the authors (T. Røynstrand) in the school-based dental delivery system. After 9 years of schooling the same individuals continued to receive regular dental care by Røynstrand in his private practice. In the 9th year of schooling (1973), when the adolescents on an average were 15 ± 0.3 years old, a first set of upper jaw and lower jaw dental stone casts (Vel-Mix) was obtained for each individual. Alginate impressions (Xantalgin) in perforated stock trays were used. In 1985, when the individuals on an average were 27 ± 0.7 years old, a second set of stone casts was obtained, using the same methods and materials as in 1973. Bite registrations were made from relatively hard baseplate wax. The two sets of stone casts were used to measure vertical overbite (OB) and horizontal overjet (OJ). The measurements, made in accordance with the detailed specifications of Solow (4), were taken with the teeth in intercuspal position using a sliding caliper (Helios) equipped with a dial gauge. The determinations were made to the nearest 1/10th mm. The OB and OJ measurements were made twice in the 1973 set and the 1985 set of casts. The hypothesis of no within-examiner difference between the repeat measurements was tested by means of paired *t* tests. Pearson's correlation coefficients were calculated to examine how well the two replicate measurements preserved rank order with regard to the variables being measured. The method error (s_i) of the duplicate measurements were calculated by using the formula: $s_i = \pm\sqrt{\Sigma d^2/2N}$, in accordance with Dahlberg (5), where d is the difference between the two determinations and N the number of replicates. The results of the calculations showed that the correlation coefficients were high and the differences between the series of measurements not statistically significant (Table 1). The method errors (s_i) were fairly high, and the means of the double determinations for each subject in the 1973 set and the 1985 set were used in the statistical analyses of the results. At the age of 15 years the average number of teeth in the upper jaw was 13 ± 0.8 and in the lower jaw 13 ± 1.0. In 1985, at the age of 27 years, the average number was 14 ± 0.9 in both jaws. The participants had not received orthodontic treatment.

Table 1. Distribution of the differences, correlations, and errors of the method for the duplicate measurements on the casts

Variable	n	$\bar{d}$	SD ($\bar{d}$)	t_d	p	$r_{(p)}$	$s_{(i)}$
OB_{73}	51	0.04	0.37	0.89	0.38	0.95	0.26
OB_{85}	51	0.11	0.61	1.36	0.18	0.84	0.44
OJ_{73}	51	0.08	0.49	1.18	0.24	0.93	0.35
OJ_{85}	51	0.02	0.35	0.44	0.67	0.95	0.24

Assessment of tooth wear for the central incisors of the upper and lower jaw was made on the casts in accordance with a graded scale (Table 2). The 1973 set of stone casts and the 1985 set were measured twice to assess examiner reliability and consistency in scoring incisal wear.

The percentage of agreement of wear for the examiner (J. Silness) was 84.8% for the 1973 set and 85.7% for the 1985 set. The kappa values in accordance with the guidelines of Landis & Koch (6) were 0.72 and 0.71, respectively (Table 3). For descriptive purposes the score of the individuals may be obtained by adding up the scores of the four incisors to give a total score. A mean score for the individual can also be obtained by adding up the scores and dividing by the number of teeth examined. To carry out the analysis for this paper, two data sets (a 1973 set and an 1985 set) were compiled to describe longitudinally by central incisors of the upper and lower jaw the associations between OB and OJ and incisal wear (IwI). In addition, the association between IwI and

Table 2. Graded scale for the assessment of incisal wear in upper and lower jaw central incisors: incisal wear index (IwI)

1. Developmental incisal notches (the mamelons) disappeared.
2. Clearly outlined smooth incisal wear facets.
3. Loss of substance with excavation along the incisal edge ('ditching').

Table 3. Distribution of scores for incisal wear index (IwI) in 1973 and 1985 in reliability studies

	IwI Scores 1973 2nd examination			
1st/2nd	1	2	3	Total
1	102	18	0	120
2	5	72	2	79
3	0	4	1	5
Total	107	94	3	204

p(obs) = 0.85; p(exp) = 0.48; kappa = 0.72.

	IwI Scores 1985 2nd examination			
1st/2nd	1	2	3	Total
1	9	11	0	20
2	1	102	10	113
3	0	9	62	71
Total	10	122	72	204

p(obs) = 0.84; p(exp) = 0.45; kappa = 0.71.

incisal occlusion (OB/OJ) as described by Silness & Røynstrand (7) was examined.

Statistical methods

The observations based on the 1973 set of casts will be referred to as OB_{73}, OJ_{73}, OB/OJ_{73}, and IwI_{73}. Likewise, observations based on the 1985 set will be referred to as OB_{85}, OJ_{85}, OB/OJ_{85}, and IwI_{85}. For the analysis of the results the following statistical methods were used: t test for paired samples (t_d), Pearson's product moment correlation (r_p), Spearman's rank correlation coefficient (r_s), and chi-square of association.

For the analysis of the OB_{73}–IwI_{85} relations the participants were allocated to one of three OB groups: group 1, $OB_{73} \leq 2.99$ mm; group 2, OB_{73} 3.00–4.0 mm; and group 3, $OB_{73} > 4.0$ mm.

For the OJ_{73}–IwI_{85} analysis the grouping was as follows: group 1, $OJ_{73} < 2.75$ mm; group 2, OJ_{73} 2.75–4.0 mm; and group 3, $OJ_{73} > 4.0$ mm.

For the OB/OJ_{73}–IwI_{85} analysis the grouping was as follows: group 1, the OB/OJ_{73} ratio ≤ 0.80; group 2, the OB/OJ_{73} ratio 0.81–1.20; and group 3, the OB/OJ_{73} ratio ≥ 1.21.

The data were tabulated in 3 × 3-fold and 3 × 2-fold tables. When chi-square was statistically significant, the nature of the association was studied by computing the percentage distribution of the row classification within each column (8).

A significance level of 5% was used for rejection of the null hypothesis. The results of the analyses showed that only minor non-systematic differences between the genders occurred. Because of this the data for the genders were combined in the analyses.

Results

Vertical overbite (OB) (Table 4)

The results of the measurements showed that the average OB_{73} was 3.58 ± 1.17 mm and the average OB_{85} was 3.01 ± 1.01 mm. The mean difference, 0.57 ± 0.87 mm, was statistically significant ($p < 0.001$). The individual differences between OB_{73} and OB_{85}—that is, ($OB_{73} - OB_{85}$)—were correlated with the OB_{73} measurements in the same individuals. The correlation coefficient was positive and statistically significant ($p < 0.001$). Thus, relatively large OB_{73} values were accompanied by relatively large reductions of the OB_{85} values, and relatively small OB_{73} values by relatively small reductions of the OB_{85} values.

Horizontal overjet (OJ) (Table 4)

The average OJ_{73} was 3.30 ± 1.27 mm, and the average OJ_{85} 2.96 ± 1.18 mm. The mean difference was 0.34 ± 0.76 mm, which was statistically significant ($p < 0.003$). The individual differences, $OJ_{73} - OJ_{85}$, were correlated with the OJ_{73} dimensions in the same individuals. The results of the calculation showed that the correlation coefficient was positive and statistically significant ($p < 0.003$), indicating that comparatively large OJ_{73} values were accompanied by comparatively large reductions in the OJ_{85} dimensions, and relatively small OJ_{73} values went with relatively small OJ_{85} reductions.

Table 4. Statistical results

Comparison		Results	DF	p
Diff.:	OB_{73} versus OB_{85}	$t_d = 4.70$	49	<0.001
Corr.:	OB_{73} versus $(OB_{73} - OB_{85})$	$r_p = 0.538$	49	<0.001
Diff.:	OJ_{73} versus OJ_{85}	$t_d = 3.15$	49	<0.003
Corr.:	OJ_{73} versus $(OJ_{73} - OJ_{85})$	$r_p = 0.410$	49	<0.003
Corr.:	OB_{73} versus OJ_{73}	$r_p = 0.318$	49	<0.03
Corr.:	OB_{85} versus OJ_{85}	$r_p = 0.349$	49	<0.02
Diff.:	OB/OJ_{73} versus OB/OJ_{85}	$t_d = 1.51$	49	=0.14
Corr.:	OB/OJ_{73} versus OB/OJ_{85}	$r_p = 0.722$	49	<0.001
Diff.:	IwI_{73} versus IwI_{85}	Chi-square = 134.70	2	<0.001
Corr.:	IwI_{73} versus IwI_{85}	$r_s = 0.679$	49	<0.001
Diff.:	IwI_{73}max versus IwI_{73}mand	Chi-square = 8.10	1	<0.005
Diff.:	IwI_{85}max versus IwI_{85}mand	Chi-square = 3.22	2	=0.19
Assoc.:	OB_{73} versus IwI_{85}	Chi-square = 24.76	4	<0.001
Assoc.:	OJ_{73} versus IwI_{85}	Chi-square = 3.86	4	=0.42
Assoc.:	OB/OJ_{73} versus IwI_{85}	Chi-square = 7.36	2	<0.03

Vertical overbite (OB) versus horizontal overjet (OJ) (Table 4)

The correlation between OB_{73} and OJ_{73} was positive and statistically significant ($p < 0.03$). That was the case also for OB_{85} and OJ_{85} ($p < 0.02$).

OB/OJ ratio (Table 4)

The average OB/OJ_{73} ratio was 1.21 ± 0.55, and the OB/OJ_{85} ratio 1.12 ± 0.51. The mean difference of 0.08 was not statistically significant ($p = 0.14$). The correlation coefficient between the two determinations was statistically significant ($p < 0.001$).

Incisal wear index (IwI) (Table 4)

The average IwI_{85} was 8.92 ± 1.82, and the average IwI_{73} was 5.68 ± 1.56. The results of the chi-square test showed that the difference was statistically significant ($p < 0.001$). The IwI_{85} assessments contained the higher percentages of scores 2 and 3 and the lowest percentage of score 1 (Table 3). Comparison between the lower and upper jaw showed that the average of the lower jaw was $IwI_{73} = 3.07 \pm 1.05$, and that of the upper jaw was $IwI_{73} = 2.60 \pm 0.85$. The result of the chi-square test showed that the difference was statistically significant ($p < 0.005$). The lower jaw registrations had the higher percentage of score 3 and the lower percentage of score 1. The corresponding comparisons for 1985 demonstrated that the average IwI_{85} of the lower jaw was 4.64 ± 1.21 and that of the upper jaw 4.27 ± 1.16. The chi-square test showed that the difference was not statistically significant ($p = 0.19$).

The results of the calculation of Spearman's rank correlation coefficient showed that IwI_{73} and IwI_{85} were positively correlated ($p < 0.001$). Thus relatively high IwI_{73} values were accompanied by relatively large IwI_{85} values and relatively low IwI_{73} were accompanied by relatively low IwI_{85} values.

IwI_{85} versus OB_{73} (Table 4)

The association between IwI_{85} and OB_{73} was statistically significant ($p < 0.001$). Group 3 ($OB_{73} > 4.00$ mm) showed the largest percentage of score 3 and the lowest percentage of score 1 (Fig. 1). Group 1 ($OB_{73} \leq 2.99$ mm) had the lowest percentage of score 3 and the highest percentage of score 1. Thus, central incisors with a relatively deep vertical overbite in 1973 showed

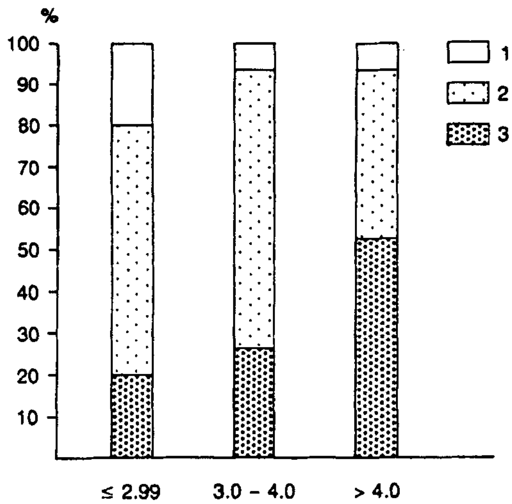

Fig. 1. Frequency distribution of percentage IwI_{85} scores in the OB_{73} groups.

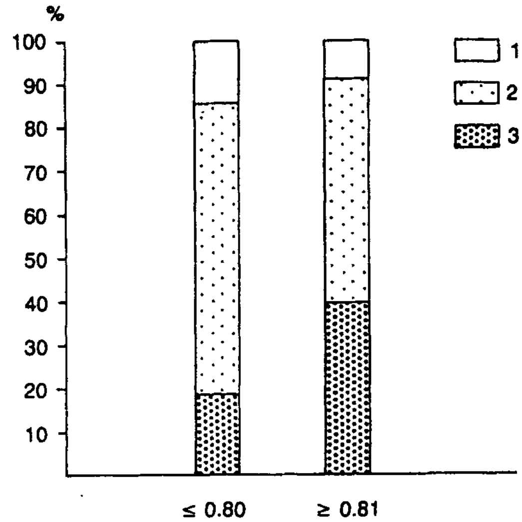

Fig. 2. Frequency distribution of percentage IwI_{85} scores in the OB/OJ_{73} groups.

the most severe wear in 1985. Conversely, central incisors with a relatively small OB_{73} showed the least severe wear in 1985.

IwI_{85} versus OJ_{73} (Table 4)

The association between IwI_{85} and OJ_{73} was not statistically significant ($p = 0.42$).

Group 3 ($OJ_{73} > 4.00$ mm) demonstrated the largest percentage of score 3 and the lowest percentage of score 1.

IwI_{85} versus OB/OJ_{73} (Table 4)

The results showed that in 1985 the wear of group 2 (OB/OJ_{73}, 0.81 – 1.20) and group 3 ($OB/OJ_{73} \geq 1.21$) was not statistically different ($p > 0.05$). Because of this groups 2 and 3 were combined for comparison with group 1 ($OB/OJ_{73} \leq 0.80$) in the chi-square analysis. The results of the comparison showed that the association between IwI_{85} and OB/OJ_{73} was statistically significant ($p < 0.03$). Group 1 ($OB/OJ_{73} \leq 0.80$) showed the higher percentage of IwI score 1 and the lower percentage of score 3 (Fig. 2). The combined group showed the highest percentage of score 3 in 1985 and the lowest percentage of score 1.

Discussion

This report provides an analysis of the longitudinal development of the size of vertical overbite (OB) and the size of the horizontal overjet (OJ) in individuals who were 15 years old at the first examination and 27 years old at the re-examination. This study also intended to investigate the longitudinal progress of incisal wear of central incisors (11, 21, 31, 41) over a period of 12 years and to relate this progress to the development of vertical overbite and horizontal overjet.

The results of the measurements with a time interval of 12 years showed that the dimensions of mean OB_{85} and the mean OJ_{85} had both been reduced as compared with the 1973 set of determinations. A reduction in the dimensions of OB and OJ with age has been demonstrated by Seipel (9) in a cross-sectional study of individuals aged 4, 13, and 21 years. In a longitudinal study of men measured when they were 12 and 20 years old, Björk (10) showed that both OB and OJ decreased with age. Seipel (9) doubted that the less pronounced vertical overbite he found in the oldest age group (21 years) could be related to attrition, since the heights of the incisors in that group showed an increase. His results were based on cross-sectional measurements in the mouth, and he mentions the 'anatomical insecurity in these measurements from the gingival margin'.

The cephalometric studies by Björk (10) showed that changes in overjet and overbite occurring with age are pronounced. According to him, they are related to, among other factors, a forward or backward displacement of the lower jaw in relation to the upper one, changes in the inclination of the incisors in one or both jaws, and the influence of soft tissue function on the occlusal development. The possible effects of dental wear were not dealt with. On the photographs he presented of occlusal age changes, incisal wear is visible.

The wear index used in this study has been derived from Pindborg's (11) description of Broca's (12) classification of occlusal wear and adapted to a relatively young convenience sample. When applied for a population in whom the developmental notches may be present, a score of zero should be indexed for incisors with the developmental notches present. In our sample they were not encountered.

The percentages of agreement for the observer were close to or within the range of 85–96%, as recommended by the WHO (13). The kappa values in accordance with Landis & Koch (6) showed 'substantial strength of agreement' (Table 3).

The results of the present study have shown that the wear of central incisors is progressive, with an increase in severity with age. This observation confirmed clinical experience and findings (11). The observation that mandibular incisors in 1973 demonstrated more wear than maxillary incisors should probably be related to the fact that permanent mandibular incisors clinically erupt about 1 year earlier than maxillary central incisors (14–16). After 12 years the difference in wear between maxillary and mandibular central incisors had been partly but not completely reduced. It has been measured that subjects with severe dental wear use high bite forces (2) and that wear of anterior teeth is associated with maximal bite force in the incisal area (3). It is also established that in dentitions with a deep overbite the horizontal forces acting during function are larger than in dentitions with a relatively small overbite (17). Moreover, it has been shown that the size of the vertical overbite is positively correlated with the size of the incisive biting forces (18). Clinical studies have shown that a deep overbite may induce an unfavorable occlusion in natural teeth, implying pronounced attrition of anterior teeth (19). With reference to these findings it seems reasonable to assume that the positive association between vertical overbite and incisal wear found here has been influenced by the adapted bite forces.

Nyström et al. (3) in a longitudinal study of maxillary anterior teeth found that all correlations between vertical overbite and size of the wear facets were close to zero. As far as can be seen, they made cross-sectional comparisons within the age groups, whereas the results presented here came out of longitudinal comparisons in which wear in 1985 (IwI_{85}) was set against the sizes of the vertical overbite in 1973 (OB_{73}). When the horizontal overjet was analyzed singly, its association with incisal wear was weak and not statistically significant. When it was considered in combination with vertical overbite in the OB/OJ ratio, it showed a statistically significant correlation with incisal wear. It is possible that this effect should be explained in part by the correlation that exists between vertical overbite and horizontal overjet. The group with the larger ratios is 1973 showed the larger incisal wear in 1985. It has previously been shown that individuals with a large OB/OJ value had better oral hygiene in anterior teeth as measured with the plaque index (20) and a better gingival condition as measured with the gingival index (21) than individuals with a lower OB/OJ ratio (7). It was suggested that the anterior occlusal relations in individuals with a relatively higher OB/OJ ratio facilitated functional and mechanical cleaning of the anterior teeth. Further, it has recently been shown that in individuals with a relatively large overbite and a relatively small overjet resin facings in cast restorations were more severely worn incisally than facings occurring in restorations with lower OB/OJ ratios (22).

The correlation between OB/OJ_{73} and OB/OJ_{85} was high. This must be taken to mean that changes in vertical overbite with age are significantly correlated with changes in overjet and vice versa. Apparently, incisal wear of the upper incisors and incisal wear of the lower ones cooperate in maintaining the relatively high correlation over 12 years. It is generally agreed that wear of natural teeth may be caused by several factors (see, for example, Refs. 2, 3, 11, 23, 24). The results of the present study have shown that vertical overbite, horizontal overjet, and the ratio between them contribute components to the multicausal nature of the etiology of dental wear. Further, the results have shown that in 15-year-old adolescents increase in age, incisal wear, vertical overbite and incisal occlusion (OB/OJ) are predictors of wear of maxillary and mandibular central incisors. Work should be continued to elucidate the applicability of incisal wear, vertical overbite and incisal occlusion (OB/OJ) as clinical predictors of dental wear across age and population groups.

In evaluating the results, it must be borne in mind that the sample examined is a convenience sample. Relevant factors such as dietary patterns, saliva factors, and genetic factors may or may not be representative of the overall population.

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