An individual tooth wear index and an analysis of factors correlated to incisal and occlusal wear in an adult Swedish population

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The aim of the study was to introduce an individual tooth wear index and to use this index to investigate factors correlated to occlusal wear. The material consisted of 585 randomly selected dentate individuals from the community of Jönköping, Sweden, who in 1983 reached the age of 20, 30, 40, 50, 60, 70, or 80 years. The degree of incisal and occlusal wear was evaluated for each single tooth in accordance with criteria presented earlier. An individual tooth wear index, which made it possible to rank individuals in accordance with incisal and occlusal wear, was used as dependent variable to investigate factors related to incisal and occlusal wear. Of all factors analyzed, the following were found to correlate significantly with increased incisal and occlusal wear: number of existing teeth, age, sex, occurrence of bruxism, use of snuff, and saliva buffer capacity. Stepwise multiple regression analysis gave a total explanation factor of $R^2 = 0.41$. It was also possible to distinguish well between groups of individuals with and without tooth wear by means of these factors. □ *Attrition; bruxism; epidemiology; saliva; use of snuff*

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Many factors have been associated with incisal or occlusal breakdown (1)—for example, the effect of parafunction (2–4), the composition of saliva (2, 5), and the industrial environment (6–9). Some investigators have analyzed tooth wear in selected groups, such as miners or workers in ship-building yards (10, 11). Others have studied tooth wear in association with specific diseases such as anorexia nervosa (12) or dietary variables (13, 14). The influence of some morphologic relationships of the jaw has also been discussed (15, 16), as has the correlation of tooth wear to occlusal factors and temporomandibular joint (TMJ) symptoms (17, 18). The multifactorial character of dental wear makes it difficult to state the etiologic factors responsible for the wear in any individual case. However, some guidelines for dental treatment of patients with incisal and occlusal wear have been suggested (18, 19).

In an earlier study Hugoson et al. (20) showed that the number and distribution of teeth with extensive incisal or occlusal wear increased with age. There was also an increase in severity of wear with increasing age. Comparable results have been found in other studies (21, 22).

Many indices have been presented in the literature (2, 3, 20, 21, 23, 24), all representing systems for classification of tooth wear. All are based on a qualitative evaluation of the wear process, and most are combined with an estimation of exposed dentin surface or reduction of tooth length. Methods for the evaluation of wear of restorative materials have also been presented (25, 26). So far, however, an index has not been published that can be used in epidemiologic studies scoring both wear of natural teeth and restorative materials. There is also a need for an individual tooth wear index scoring the total individual incisal and occlusal wear.

The aim of this study was to introduce an individual tooth wear index with the potential to rank persons with regard to incisal and occlusal wear and to use this index to study factors related to such wear in an adult Swedish population.

Materials and methods

This investigation is part of a larger epidemiologic dental study of individuals from the community of Jönköping, Sweden (20, 27, 28), based on data from 585 dentate individuals, who in 1983 reached the age of 20, 30, 40, 50, 60, 70 or 80 years. The number of subjects examined and the age and sex distribution are presented in Table 1. For further information on selection procedures and number of non-respondents, please see Hugoson et al. (27).

The individuals were examined clinically and radiographically with regard to the health of teeth and jaws and the presence of prosthetic restorations. The clinical examinations were carried out under optimal conditions by seven dentists at the Institute for Postgraduate Dental Education in Jönköping. Before the registration procedures, all examiners were calibrated (28). A questionnaire about medical and dental health was used.

Diagnostic criteria

The extent of incisal or occlusal wear was evaluated for each single tooth in accordance with the following criteria: score 0 = no wear or negligible wear of enamel; score 1 = obvious wear of enamel or wear through the enamel to the dentin in single spots; score 2 = wear of the dentin up to one-third of the crown height; score 3 = wear of the dentin up to more than one-third of the crown height; excessive wear of tooth restorative material or dental materials in crown and bridgework, more than one-third of the crown height.

Table 1. Number of individuals examined in relation to age and sex

Age group (years)	No. of individuals		
	Women	Men	Total
20	55	45	100
30	48	50	98
40	52	47	99
50	57	42	99
60	42	42	84
70	32	38	70
80	20	15	35
Total	306	279	585

Analysis of observation errors

To check the examiners' ability to interpret the scoring of incisal and occlusal wear, interindividual comparisons were carried out. For details, please see Hugoson et al. (27).

Introduction and evaluation of an individual tooth wear index

An individual incisal and occlusal tooth wear index (I_A) was created, on the basis of the scores of incisal or occlusal wear for each tooth of the individual.

$$I_A = \frac{10 \times G_1 + 30 \times G_2 + 100 \times G_3}{G_0 + G_1 + G_2 + G_3}$$

The index is the ratio between the weighted sum of all teeth with some degree of wear and the total number of existing teeth for that individual. The purpose was to obtain one single value for the degree of incisal and occlusal tooth wear.

G_0, G_1, G_2, and G_3 = the number of teeth with score 0, 1, 2, and 3, respectively. The constants 10, 30, and 100 were chosen to reflect the differences in incisal and occlusal breakdown between teeth with scores 1, 2, and 3, respectively.

To verify the clinical validity of I_A, a separate methodologic study was performed in 16 individuals (10 men and 6 women) aged 20 to 65 years. The persons selected were patients known to have extensive occlusal wear, and they were staff members. None of the subjects had extensive prosthetic restorations. After calibration, each person was examined independently by three senior staff

members. Each single tooth was scored for incisal or occlusal wear in accordance with the criteria presented, and the I_A for each individual was calculated.

From intraoral color photographs and stone casts of the dentition of each person, each of the three examiners independently ranked the dentition of the 16 individuals by increasing severity of incisal and occlusal tooth wear. Finally, a consensus evaluation of the rankings was made.

To estimate the relationship between the ranking in accordance with the I_A and the consensus evaluation, a non-parametric statistical method, the Spearman rank correlation (29), was used.

Statistical analysis of factors related to incisal and occlusal wear

By means of the individual index (I_A), variables of importance for incisal and occlusal wear were analyzed among the 585 dentate persons taking part in the study. On the basis of clinical experience, a review of the literature (1, 2, 11–13, 21) and a preliminary analysis, the number of possible etiologic variables among those registered was reduced to those presented in Table 2.

Statistical analysis was performed with the SPSS statistics package in an IBM computer. To study variables influencing incisal and occlusal tooth wear, a multiple stepwise regression analysis (30) was used. The individual tooth wear index (I_A) was used as dependent variable. Before analysis, the I_A was transformed to its logarithm. This was done to obtain a more normal distribution of the residuals. Owing to this technical procedure, individuals with no incisal or occlusal tooth wear, a total of 133 individuals, were excluded from the statistical analysis. In addition, 42 individuals were excluded because of incomplete data for one or more of the independent variables. Thus 410 persons were included in the regression analysis. The results of the analysis are to be interpreted only for the subpopulation with positive $I_A > 0$ (group C).

To evaluate factors of importance in distinguishing individuals with no tooth wear from individuals with incisal or occlusal wear, a discriminant analysis (31) was performed. The analysis combined the values of several variables, to form the discriminant function, which in turn served as basis for the classification. The first group (group A) consisted of individuals with $I_A = 0$ (n =

Table 2. Etiologic variables used in the further statistical analyses

Variables	Scale
Age	20–80 years
Sex	Female = 1; male = 2
No. of principal meals	*n*
No. of meals in between	*n*
Bruxism	Yes = 1; no = 2
Dry mouth	Never–always (1–4)
Salivary secretion	ml/min
Salivary buffer capacity	pH
Smoker	No. of cigarettes/day
Snuffer	Yes = 1; no = 2
Early trauma to the jaw	Yes = 1; no = 2
No. of occluding teeth	24–32 = 1; 16–23 = 2; 2–15 = 3;
No. of occlusal restorations	*n*
No. of teeth	1–28
No. of principal meals containing juice, syrup, or apple	*n*
No. of meals in between containing juice, syrup, or apple	*n*

Table 3. Variables ordered by size of correlation ($p < 0.05$) in a stepwise discriminant analysis between two groups of persons: one group with no incisal and occlusal wear (group A) and one group with incisal and occlusal wear of scores 2 and 3 (group B)

Variable	Func. 1	Means	
		Group A	Group B
Sex	1.569	1.3	1.7
Age	0.059	41.9	55.5
Bruxism	−1.158	1.9	1.7
No. of teeth	0.085	22.3	19.5
No. of occlusal restorations	−0.067	12.0	10.8

N: group A = 133 subjects; group B = 87 subjects.
Func. 1 = correlation with the discriminant function.
Percentage of persons correctly classified to group A or B = 79.7%.

133), and the second group (group B) of individuals with one or more teeth with tooth wear scores of 2 or 3 ($n = 87$) (Table 3).

Results

Results of ranking by severity of incisal and occlusal wear determined from the individual tooth wear index (I_A) and the consensus evaluation are given in Table 4. The correlation, using the Spearman rank correlation coefficient, between the two measurements was 0.83, with 95% confidence limits of 0.57–0.94. Table 5 presents the results of the stepwise multiple linear regression analysis. Variables are ordered by magnitude of correlation ($p < 0.05$), with the individual tooth wear index as the dependent variable. The regression model produced a total factor of explanation (R^2) of 0.41. The most prominent variable was the number of existing teeth, which explained 29% of the variance. Persons with a reduced number of teeth showed a high I_A. Male sex, occurrence of bruxism, and increasing age also gave a high value of I_A. The use of snuff and the saliva buffer capacity also seemed to be of importance for increased incisal and occlusal wear and explained an additional 2% of the variance.

Table 4. Individual ranking of incisal or occlusal tooth wear, from slight to severe, in accordance with the individual tooth wear index and the consensus evaluation

Order of ranking	Ranking by the individual tooth wear index I_A		Ranking by the consensus evaluation, Subject no.
	Subject no.	I_A	
1	11	2.9	11
2	4	3.9	14
3	14	4.3	10
4	5	5.0	4
5	1	5.2	1
6	8	5.4	12
7	10	6.4	6
8	2	7.0	16
9	12	7.8	8
10	16	7.8	2
11	6	8.9	5
12	3	12.1	3
13	15	15.2	15
14	13	26.1	9
15	9	36.4	13
16	7	77.7	7

The variables included in the discriminant function showing a significantly ($p < 0.05$) high discriminating power between the two groups are given in Table 3. Sex, age, bruxism, number of teeth, and number of restored occlusal surfaces were variables discriminating between the two groups with and without incisal and occlusal wear. The tooth wear group (group B) showed higher mean values for age but lower mean values for number of teeth and number of occlusal restorations. Male sex and the occurrence of bruxism were variables more frequent in this group—70% males and 30% tooth grinders, respectively. The corresponding values for group A were 30% and 10%, respectively. According to the variables mentioned, 80% of the 220 individuals (groups A + B) were correctly classified.

Discussion

In epidemiologic studies with many subjects examined by several examiners, there is always some interexaminer variability. To make the classification simpler, a tooth wear index with only four degrees of wear was used. The examiners were carefully calibrated with each other before the study. An

Table 5. Variables ordered by size of correlation ($p < 0.05$) in a stepwise multiple linear regression analysis with the individual tooth wear index (I_A) as dependent variable. No. of subjects, 410

Variable	Beta	Higher index for	Change in R^2	Significance
No. of teeth	−0.059	Lower no. of teeth	0.292	$p<0.001$
Sex	0.406	Males	0.037	$p<0.001$
Bruxism	−0.473	Yes	0.033	$p<0.001$
Age	0.014	Increased age	0.026	$p<0.001$
Snuffer	−0.487	Yes	0.012	$p<0.01$
Buffer capacity	−0.082	Lower buffer capacity	0.008	$p<0.05$
Total			0.408	

Beta = standardized regression coefficient; R^2 = factor of explanation.

analysis of the observation error was made and showed good examiner agreement (20).

The index used describes well excessive wear of dentin and restorative material but has the limitation of not discriminating incisal and occlusal wear of restorative materials of degrees 0, 1, and 2. This limits the possibility of ranking slight to moderate tooth wear in individuals with occlusal restorations.

The aim of the present investigation was to study factors related to incisal and occlusal wear in adults from an epidemiologic point of view. To do that, it was necessary to introduce an individual tooth wear index with the potential to rank persons with regard to occlusal wear. The individual tooth wear index states the ratio between the weighted sum of all teeth with some degree of tooth wear and the total number of existing teeth for that individual. This relation will give a comparative measurement of the tooth wear in that individual. The values of the constants G_1, G_2, and G_3 were chosen to strengthen the difference in wear between teeth with scores 1, 2, and 3, respectively, in order to increase the discriminating power of the I_A index. To emphasize the clinical and therapeutic importance of advanced wear, the difference between score 2 and 3 was deliberately made greater than the arithmetic difference between scores 0, 1, and 2.

We wanted to assess index validity by comparing what might be called administrative decisions based on index scores with those resulting from the subjective judgement of clinicians. Thus, the index scores and clinical judgements of severity of the occlusal wear could be independently obtained for a sample of individuals (16 casts). The objective of the test was to rank the individuals in order of priority for treatment. An attempt was thus made to substitute an index score for the clinical judgement of severity of the occlusal breakdown.

There was good correlation between the ranking of subjects by the I_A and the consensus evaluation of tooth wear for the same person. The I_A therefore provides a valid measure of individual tooth wear and was considered useful as the dependent variable in evaluating factors correlated to occlusal tooth wear.

Originally, many possible etiologic variables for tooth wear from the questionnaire and the clinical examination were selected for evaluation. On the basis of clinical experience, review of the literature, and a preliminary analysis, however, the variables were reduced to 16. This was done to reduce the problem of mass significance—that is, the risk of false significance.

The advantage of using a stepwise multiple regression analysis as compared with more conventional statistical methods is the possibility of elucidating the co-variation of the variables. This is of importance when examining a phenomenon of multifactorial character. Otherwise, in an analysis of different

variables separated from each other, severe misinterpretations of the importance of each factor can be made owing to co-variation. Examples of such co-variation are the number of teeth and age (28, 32) and the use of snuff, saliva buffer capacity, and sex (33, 34). However, no variables should be excluded from the analysis, since this might cause an overestimation of the importance of another.

The use of a logarithmic function excluded all subjects with an $I_A = 0$ from the regression analysis, which is why the results only present variables related to increased incisal and occlusal wear. In contrast to the regression analysis, the stepwise discriminating analysis was used to study variables distinguishing between groups of individuals without tooth wear and groups of individuals with tooth wear scores of 2 and 3. The I_A score was thus not used in this analysis. In spite of this, the same variables were found to correlate with incisal and occlusal wear or to discriminate between groups of individuals with and without tooth wear, which strengthens the importance of these variables as etiologic factors for incisal and occlusal wear.

The regression analysis gave a high explanation factor ($R^2 = 0.41$), considering that this was biologic material. From a statistical point of view the most prominent variable for increased tooth wear was the number of teeth ($R^2 = 0.29$). A reduced number of teeth has earlier been related to occlusal wear (4, 11). An explanation for this might be that the influence of normal masticatory function on tooth wear will be increased when the number of teeth is reduced. Age and sex have also been described in the literature as important factors for incisal and occlusal wear (20–22), with tooth wear increasing with age and males showing more wear than females. A high prevalence of bruxism in individuals with occlusal wear has also been found in other studies (1, 2, 10). On the other hand, Seligman et al. (17) found no such correlation in their investigation of 222 individuals aged 19–40 years. The role of saliva for occlusal wear has only partly been investigated in humans (2, 5, 35). In one investigation the buffer capacity but not the saliva secretion was found to be of significant importance for extended tooth wear (2). Excessive tooth wear as an effect of snuff or smokeless tobacco has earlier been discussed (36). The snuff tobacco contains a certain amount of silica compound (37), which may have an abrasive effect on the teeth.

The discriminant analysis gave five significant variables that separated a group of individuals with no tooth wear from a group of individuals with occlusal wear of scores 2 or 3. The variables provided good discrimination between the groups, as 80% of the subjects could be correctly grouped with the use of these variables.

The obvious multifactorial etiology of incisal and occlusal wear has been presented earlier in the literature (1, 4, 18). In a cross-sectional study like the present one, no effects of specific industrial environments or of specific illness could be expected, owing to the probably low occurrence in a statistical sample of persons aged 20–80 years.

The factors that were found to correlate to increased incisal and occlusal wear in this study—reduced number of teeth, age, sex, bruxism, the use of snuff, and the saliva buffer capacity—could all be supported by findings in other studies. The reasonably high factor of explanation ($R^2 = 0.41$) for the regression analysis and good correlation with the variables found significant in the discriminant analysis emphasize the clinical significance of these factors for increased incisal and occlusal wear.

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