Risk Factors for High Occlusal Wear Scores in a Population-Based Sample: Results of the Study of Health in Pomerania (SHIP)

Olaf Bernhardt, Dr Med Dent^a/Dietmar Gesch, Dr Med Dent^b/Christian Splieth, Dr Med Dent^a/ Christian Schwahn, Dipl Mat^c/Florian Mack, Dr Med Dent^d/Thomas Kocher, Dr Med Dent^e/ Georg Meyer, Dr Med Dent^f/Ulrich John, Dr Phil^g/Bernd Kordass, Dr Med Dent^h

> Purpose: Using a population-based sample of the cross-sectional epidemiologic "Study of Health in Pomerania" (SHIP), this study evaluated whether certain occlusal and sociodemographic factors besides age and gender are risk factors for high dental wear. Materials and Methods: Medical history and dental and sociodemographic parameters of 2,529 dentate subjects selected representatively and according to age distribution were checked for correlations with the occurrence of high occlusal wear symptoms using a multivariate logistic regression model. Occlusal wear was recorded using the attrition index by Ekfeldt et al and was age adjusted by determining high occlusal wear for every 10-year age group as index values \ge 90th percentile. **Results:** The following independent variables were found to be correlated with high occlusal wear: male gender, odds ratio 2.2; frequent bruxism, odds ratio 2.5; loss of molar occlusal contact (Eichner classification), odds ratio from 1.5 to 3.1; edge-to-edge relation of incisors, odds ratio 1.7; unilateral buccolingual cusp-to-cusp relation, odds ratio 1.8; and unemployment, odds ratio 1.6. In contrast, anterior cross-bite, unilateral posterior crossbite, and anterior crowding were protective for high occlusal wear levels, as shown by significantly reduced odds ratios. Gender-separated analysis showed that self-reported bruxism was a risk factor only for men. Conclusion: In addition to some occlusal factors, the main factors associated with occlusal wear were bruxism and gender. Int J Prosthodont 2004; 17:333-339.

Occlusal wear is defined as loss of substance on opposing units or surfaces as a result of attrition or abrasion.¹ It can occur because of contact of occluding surfaces (tooth-to-tooth contact) or contact of teeth with other materials introduced into the mouth.^{2,3} Epidemiologic studies have shown that the occurrence of occlusal wear increases with age.^{4,5} However, strong occlusal wear is low in industrialized countries.^{6,7} Nevertheless, several authors state an increase of occlusal wear in these populations for children and adults.^{3,8-10} Epidemiologic studies on adults to confirm this statement are rare, and those that do exist did not use random samples and investigated only a few subjects.¹¹ Most of the larger studies were performed up to the mid-1990s.⁶⁻⁸

High occlusal wear may become an esthetic problem. Because of the loss of the vertical dimension, the occlusal situation also can be adversely affected.⁸ A relationship between temporomandibular disorders (TMD) and occlusal wear was not found.^{12,13} Treatment of extremely worn teeth

^aAssistant Professor, Department of Operative Dentistry, Dental School, University of Greifswald, Germany.

^bAssistant Professor, Department of Orthodontics, Dental School, University of Greifswald, Germany.

^cResearch Assistant, Dental School, University of Greifswald, Germany.

^dAssistant Professor, Department of Prosthodontics, Dental School, University of Greifswald, Germany.

^eProfessor, Unit of Periodontology, Dental School, University of Greifswald, Germany.

^fProfessor and Head, Department of Operative Dentistry, Dental School, University of Greifswald, Germany.

⁹Professor and Head, Institute of Epidemiology and Social Medicine, University of Greifswald, Germany.

^hProfessor and Chair, Preclinic Dental Education/Community Dentistry in the Polyclinic of Prosthodontics and Dental Material Department of Prosthodontics, Dental School, University of Greifswald, Germany.

Correspondence to: Dr Olaf Bernhardt, University of Greifswald, Department of Restorative Dentistry, Rotgerberstrasse 8, 17487 Greifswald, Germany. Fax: + 49 3834 867171. e-mail: obernhar@uni-greifswald.de

is complicated, results in the restoration of the whole dentition, and is thus quite expensive.^{14,15}

In general, there has been a strong decline in caries and an improvement of oral health in industrialized countries in the past years.^{16–18} Hence, a longer period of tooth function results, and age-dependent occlusal wear may become a relevant problem in higher age groups.¹⁹ High occlusal wear scores are also found among younger individuals.⁸ Besides age, the main risk factors of dental wear are bruxism and the number of remaining teeth.^{7,20} Several factors such as diet, saliva buffering capacity, and social parameters are also discussed.¹¹

The reported signs of an increase in occlusal wear need further substantiation by evaluation of a random population-based sample. Furthermore, the effect of several risk factors for occlusal wear should be weighted. The aim of the present study was to determine the prevalence of occlusal wear within a population-based sample of the cross-sectional epidemiologic "Study of Health in Pomerania" (SHIP) and to evaluate whether certain occlusal and sociodemographic factors besides age and gender are risk factors for high occlusal wear.

Materials and Methods

Among 4,310 randomly selected subjects, 2,529 dentate individuals were examined from October 1997 to May 2001 within SHIP²¹ and screened for risk factors for high occlusal wear levels using a multivariate logistic regression model. SHIP is a population-based cross-sectional study intended to systematically describe the prevalence of and risk factors for diseases common in the population of Pomerania in northern Germany. The gross sample comprised 6,267 subjects with an age range of 20 to 79 years. The response rate of the study was 68.8% overall and 71.3% for the age groups 20 to 74 years. An analysis of nonresponders found that the main reasons for nonparticipation were disinterest (39.7%), health problems (23%), adequate available medical care (11.6%), lack of time (16.7%), fear of examination results (3%), and other reasons (6%). Sample recruiting was performed randomly via residents' registration office files. The study consisted of four parts: a medical and a clinical dental examination including the functional analysis, an interview, and a questionnaire.

Clinical dental examinations were performed by eight calibrated examiners. Training of the examiners and consensus discussions were carried out before the study started and took place twice a year while the study was running. Inter- and intraexaminer reliability were checked and have already been published.²²

For occlusal wear calculations, only the data from dentate subjects could be included in the regression model. Subjects were excluded if in two or more sextants (the complete dentition was divided into six sextants, two anterior and four posterior), three or more teeth per sextant were missing (excluding third molars), regardless of whether the missing teeth had been prosthetically replaced. This means that the absolute minimum number of remaining teeth necessary for including subjects in the model was 15. This limitation was necessary to determine different types of malocclusion.

Occlusal wear was recorded using the method by Hugoson et al⁷: 0 = no or minimal wear (uncertain wear); 1 = attrition of enamel down to dentin spots; 2 = wear of the dentin down to one third of the crown height; and 3 =wear of the dentin more than one third of the crown height or excessive wear on dental materials. The individual tooth wear (IA) was calculated using the attrition index by Ekfeldt et al,²³ using the following formula:

$$(10G_1 + 30G_2 + 100G_3)/(G_0 + G_1 + G_2 + G_3)$$

where G_0 , G_1 , G_2 , and G_3 = number of teeth with occlusal wear scores of 0, 1, 2, and 3, respectively. High occlusal wear was first determined as index values \geq 90th percentile (total sample), and then as index values \geq 90th percentile for every 10-year age group. Furthermore, mean values of the wear score were calculated to illustrate the high-wear group and make the prevalence comparable with other studies.

The following variables were included in the logistic regression model:

- Symptoms of malocclusion: angle Class II and III, anterior and posterior crowding, buccolingual cusp-tocusp relation, edge-to-edge relation of the incisors, and anterior/posterior cross-bite.
- Existence of remaining natural occlusal supports according to the Eichner index.²⁴ The Eichner index was summarized as: A = no loss of natural occlusal supports; and B1 to B4 = loss of one to four (all) natural occlusal support areas.
- Symptoms of TMD (tenderness or palpation pain in the temporomandibular joint [TMJ] or masticatory muscles).
- 4. Sociodemographic and anamnestic parameters (taken from the interview): marital status (single, married, separated, divorced), higher education level (high school diploma), frequent bruxism, frequent heartburn, daily intake of acidic soft drinks, daily intake of sweets, and current or previous unemployment.

For details of the clinical dental examination and interview, see Hensel et al.²²

For the regression analysis, the independent variables were checked for significance by age category and gender using a backward stepwise analytic method. A *P* value < .100 was required for entering the model, and statistical significance was defined as *P* values < .050. Analysis was performed using SPSS logistic regression (SPSS) with the

Age	Total te	eeth	Wear so	core 1	Wear so	ore 2	Wear sc	ore 3	Occlus	al attritio	n index
group (y)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P 90
20–29	28.4	2.4	44.8	24.1	8.1	12.0	0.4	2.4	7.6	4.6	12.9
30-39	26.7	3.0	44.1	24.2	14.0	16.6	0.6	3.4	10.4	6.4	18.3
40-49	25.4	3.3	40.1	24.4	20.3	20.6	1.1	4.4	13.1	8.2	23.0
50-59	24.1	3.4	33.8	23.3	29.9	22.2	2.7	7.8	18.0	11.3	28.6
60-69	20.7	3.3	33.0	25.9	32.2	25.6	4.8	12.1	20.7	14.6	39.8
70–79	21.8	2.8	34.4	28.5	31.9	26.0	5.0	11.0	22.4	13.9	44.3

 Table 1
 Mean and Standard Deviation (SD) of Tooth Wear Parameters

P 90 = 90th percentile.

 Table 2
 Mean and Standard Deviation (SD) of Occlusal Wear Scores According to Age Group

Age	Total sample		Men		Women		High-wear group	
group (y)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
20–29	0.6	0.3	0.7**	0.3	0.6**	0.3	1.2	0.2
30-39	0.8	0.4	0.9*	0.4	0.8*	0.3	1.5	0.2
40-49	1.0	0.4	1.0*	0.4	0.9*	0.4	1.6	0.3
50-59	1.2	0.4	1.3*	0.4	1.1*	0.4	1.9	0.4
60-69	1.3	0.5	1.4*	0.5	1.2*	0.5	2.2	0.3
70–79	1.4	0.5	1.4	0.5	1.4	0.5	2.1	0.2

**P < .005, *P < .001; Mann-Whitney U test.

colinearity diagnostics option, and assumptions of regression were checked. All statistical assumptions were met. In a first step, the 90th percentile of the attrition index was calculated over all age groups and gender and used as a dependent variable in the regression model. In a second step, the 90th percentile of the attrition index adjusted for the age groups was used in the analysis to exclude the influence of age on attrition. This method delivered associations for all investigated variables with the dependent variable "high occlusal wear." These associations were expressed as odds ratios (OR), eg, a 1:1 ratio implied no increased risk. The coefficient of determination, Nagelkerke R^2 , a factor that indicates the explanatory quality of the model, was also computed.²⁵ Prevalence data were given to describe the sample structure. Age group-adjusted 90th percentile scores of the attrition index were used to determine high occlusal wear. Descriptive statistics were done with cross-table calculations. All calculations were performed with SPSS 11.0.

Results

Mean numbers for score 1 varied between 33% and 45%, for score 2 between 8% and 32%, and for score 3 between 0.4% and 5%. Scores 2 and 3 increased with age. The 90th percentile over all age groups for all subjects was 24.3 (Table 1). Mean values of all scores varied between 0.6 and 1.4. Men showed significantly higher scores than women (with the exception of the highest age group). Mean scores of the high-wear group were nearly twice as high as the mean scores of the whole sample according to the age groups (Table 2).

Table 3Sample Structure (n Total = 2,529, n High Wear =252) and 90th Percentile of Attrition Index, Adjusted for Age

	Freq	uency tal	Frequency within high-wear group (≥ 90th percentile)			
Variable	n	%	n	%		
Gender						
Male	1,220	48	166	66		
Female	1,309	52	86	34		
Age group (y)						
20-29	572	23	57	23		
30-39	673	27	67	27		
40-49	549	22	55	22		
50-59	462	18	46	18		
60-69	214	8	21	8		
70-79	59	2	6	2		
No. of teeth						
15-19	115	4	14	6		
20-24	698	28	102	40		
> 25	1,716	68	136	54		
Eichner classi	fication					
A	1,979	78	173	69		
B1	334	13	41	16		
B2	163	6	28	11		
B3	45	2	10	4		
B4	8	< 1	0	0		

Sample structure and prevalence of the variables that were included in the logistic regression model are given in Tables 3 to 5. The high occlusal wear group was adjusted for every 10-year age group, as can be seen in the percentages given in Table 3. Gender distribution was nearly equal in the total sample, but there were nearly twice as many men as women in the case group. The

	Frequ tot	iency al	Frequency within high-wear group (≥ 90th percentile)		
Variable	n	%	n %		
Anterior open bite	77	3	5 2		
Anterior cross-bite	101	4	3 1		
Anterior crowding	990	39	63 25		
Edge-to-edge bite of incisors	154	6	24 10		
Unilateral buccolingual cusp-to-cusp relation	726	29	86 34		
Bilateral buccolingual cusp-to-cusp relation	175	7	16 6		
Unilateral posterior cross-bite	572	23	47 19		
Bilateral posterior cross-bite	133	5	11 4		
Angle Class II/1	597	24	55 22		
Angle Class II/2	230	9	14 6		
Angle Class III	96	4	5 2		

Table 4Occlusal Factors (n High Wear = 252) and 90thPercentile of Attrition Index, Adjusted for Age

Table 5 Anamnestic, Social, and Denavioral Fa

	Frequ tot	ency al	Frequenc high-wea (≥ 90th pe	Frequency within high-wear group (≥ 90th percentile)		
Variable	n	%	n	%		
Tenderness in TMJ or masticatory muscles	510	20	35	14		
Frequent bruxing Marital status	189	8	37	15		
Single	685	27	50	20		
Married	1,552	61	169	68		
Divorced	180	7	18	7		
Other	109	4	10	4		
Unemployment	1,090	43	132	52		
Soft drink consumption						
Daily	356	14	46	18		
Several times a week Fruit juice consumption	302	12	39	13		
Daily	963	38	95	38		
Several times a week	717	28	63	25		
Strong heartburn	75	3	10	4		
Toothbrushing						
3 times daily	184	7	23	9		
2 times daily	1,965	78	174	69		
1 time daily	350	14	50	20		

number of remaining teeth per subject of the dentate sample group was not less than 15, as stipulated by the definition of the orthodontic variables. Most of the subjects belonged to Eichner class A, no loss of natural occlusal support zones.

In Table 6, the logistic regression model is shown, using the 90th percentile over all age groups as cases.

Because of the backward stepwise method, only variables with a *P* value \leq .100 remained in the model. Male gender, age, loss of natural occlusal support areas, some occlusal factors, self-reported bruxism, and unemployment were significantly related to high occlusal wear. Men had a higher risk of suffering from high occlusal wear than did women (OR 2.2). There was a clear dose/response effect for age up to the 60- to 69-year-old age group and for the loss of one and two natural occlusal support areas (Eichner class B1 OR 1.9 and B2 OR 2.7). Age showed high ORs within all age groups compared to baseline. In addition to the occlusal factor "unilateral buccolingual cuspto-cusp relation" with an increased OR for high occlusal wear (1.9), unilateral posterior cross-bite and anterior and lateral crowding seemed to be protective, as reduced ORs showed. Bruxism was strongly related to high occlusal wear (OR 2.2), while unemployment showed only a slightly elevated OR (1.6). The explanatory quality (Nagelkerke R^2) of this model was 32%.

After exclusion of age as a risk by adjusting the 90th percentile of the attrition index to the age groups, additional occlusal factors became significant and entered the logistic regression model: edge-to-edge bite of the incisors (OR 1.7) and anterior cross-bite (OR 0.2). Furthermore, "tenderness of the masticatory muscles or the TMJ" showed a reduced OR (0.7). The other variables did not change noticeably (Table 7). Because of exclusion of age, the explanatory quality of the model was reduced to 12%.

Gender-separated analyses revealed that bruxism (OR 3.0), unilateral buccolingual cusp-to-cusp relation (OR 1.7), and edge-to-edge relation of the incisors (OR 2.3) were risk factors for high occlusal wear only in men.

Discussion

There are several methods and indices to assess tooth wear.^{6,7,11,12,20,26–28} Some authors have also used casts or photographs to determine the loss of dental hard tissue.^{12,20,28–30}

Because of the extensive examination, our study focused only on occlusal wear, assessing mainly attrition and abrasion, although erosion also affects occlusal surfaces.²⁶ Assessment of tooth wear was performed using the method of Hugoson et al,⁷ despite its limitations in assessing occlusal wear in restorations, to be comparable with other authors who also used graded scores to assess occlusal tooth wear.^{6,7,11,28,30,31} The subsample was selected using the criteria for the assessment of symptoms of malocclusion because occlusal factors should be evaluated as risk factors of occlusal wear. Therefore, only dentate persons who had at least 15 teeth were included in the study.

Because of the different measurement scales and techniques used in the studies and the different methods

in presenting the results, it is difficult to compare prevalence. In spite of this, the prevalence of occlusal wear found in the present study was certainly higher than that of Hugoson et al,⁷ but still lower than that found for Saudi,²⁸ Indian,³⁰ and Mexican-American and European-American populations,¹¹ and it may be closest to the data of Salonen et al.⁶

To determine risk factors for occlusal wear, it was necessary to calculate an index for detected wear scores. We used the attrition index by Ekfeldt et al,²³ which should be a reliable tool to rank persons with occlusal wear and to differentiate between the wear scores. Because of the multifactorial character of the development of tooth wear, a stepwise logistic regression analysis was used to determine factors that are related to occlusal wear. The explanatory quality of the first model, which included age, was high, considering that this is a biologic system.³²

There is no doubt that occlusal wear increases throughout life, a fact confirmed in the present study.^{6–8,11,26} Only Seligman et al¹² did not find a correlation between age and attrition, but they did not use a randomly selected sample with different age strata.¹² Age seems to be the most important factor in the progression of occlusal wear. ORs became very high for higher age groups, and after exclusion of age, Nagelkerke R^2 decreased by about two thirds, which means that two thirds of the whole model are explained by age. It is furthermore generally accepted that men have higher wear levels than women, an assumption also confirmed by our results.^{6–8,11,12} These differences may be explained by stronger masseter muscle function in men.¹²

The risk factors for occlusal wear identified in the present study were stable or became more significant after exclusion of age. Self-reported bruxism was strongly related to occlusal wear, but only for men. Others^{11,20,23} also found high correlations between self-reported bruxism and occlusal wear. However, Seligman et al¹² found no such relation. These authors assume that prevalence of self-reported bruxism is highly sensitive to data collection methods and that anamnestic reports do not identify a large percentage of bruxists.

Of all the occlusal factors we investigated, only those that alter the normal or maximal interocclusal contacts were related to occlusal tooth wear, ie, an edge-to-edge or cusp-to-cusp situation of the incisors or molars. Angle Class II or III malocclusion did not show a relation to occlusal wear, which was also reported by Seligman et al,¹² whereas a 20-year follow-up could show that angle Class II malocclusion in childhood predicts increased tooth wear in adulthood.³³

Interestingly, an examination of a skull sample from the 15th and 16th centuries with advanced dental wear showed only a few dental anomalies and no skeletal malocclusions.³⁴ Angle Class II occlusion, deep bite, crowding, spacing, and lateral cross-bite occurred with

 Table 6
 Odds Ratios of Significant Variables for Men and Women*

Variable	Odds ratio	95% confidence interval	P value
Women [†]			
Men	2.5	1.8-3.4	< .001
Age group (y)			
20–29 [†]			
30-39	2.4	0.9-6.0	.062
40-49	5.8	2.4-13.9	< .001
50–59	15.1	6.4-35.7	< .001
60-69	34.8	14.1-85.7	< .001
70–79	29.6	10.5-83.3	< .001
Eichner classification			< .001
A [†]			
B1	1.9	1.3-2.7	.010
B2	2.7	1.7-4.2	< .001
B3	2.1	1.0-4.3	.050
Unilateral posterior cross-bite	0.7	0.5–1.0	.054
Anterior crowding	0.5	0.4-0.8	.001
Posterior crowding	0.4	0.3-0.6	< .001
Unilateral buccolingual cusp-to-cusp relation	1.9	1.4-2.7	< .001
Bruxism	2.2	1.3-3.5	.002
Unemployment	1.6	1.2–2.3	.005

*Nagelkerke R² 0.32, 90th percentile of attrition index, not age adjusted.

Reference group.

 Table 7
 Odds Ratios of Significant Variables for Men and Women*

Variable	Odds ratio	95% confidence interval	<i>P</i> value
Women [†]			
Men	2.2	1.7-3.0	< .001
Eichner classification			.001
A [†]			
B1	1.5	1.0-2.3	.030
B2	2.2	1.4-3.5	.001
B3	3.1	1.4-6.7	.005
Anterior cross-bite	0.2	0.1-0.7	.030
Unilateral posterior cross-bite	0.6	0.4-0.8	.005
Anterior crowding	0.6	0.5-0.9	.005
Unilateral posterior crowding	0.4	0.3-0.6	< .001
Edge-to-edge bite of incisors	1.8	1.1–2.9	.028
Unilateral buccolingual cusp-to-cusp relation	1.8	1.3–2.5	< .001
Tenderness in TMJ or masticatory muscles	0.7	0.5–1.0	.070
Bruxism	2.3	1.5-3.5	< .001
Unemployment	1.6	1.2-2.1	.003

*Nagelkerke *R*² 0.12, 90th percentile of attrition index, adjusted for age. [†]Reference group.

significantly lower frequencies in this skull sample compared to a present-day population. The author suggested that the dietary transition from hard to soft food is the most probable cause of the increased occlusal variation and high frequency of malocclusion in present-day populations.

As a risk factor for occlusal wear, the number of remaining teeth was also identified by Ekfeldt et al.²³ To a certain degree, we also included number of teeth in our study, using the Eichner occlusal index.²⁴ In our study, a dose/response effect between the decreasing number of occluding contact areas and an increase of the attrition index was observed.

As in earlier studies,^{8,13} we did not find any positive relation between tenderness of the masticatory muscles and high occlusal wear. Instead, subjects with tenderness of the masticatory muscles or TMJ showed almost significantly less occlusal wear. It can be concluded that people who are affected by bruxism, whether self-reported or evident as occlusal wear facets, do not necessarily develop tenderness of the muscles or joint. It is more likely that tenderness prevents the development of wear facets or prevents bruxism.

Several authors discuss the value of erosive nutrients for the development of dental wear because erosion also occurs on occlusal surfaces.^{11,26,35,36} In agreement with Pigno et al,¹¹ the present study found no influence of soft drinks or fruit juices on the development of occlusal wear.

Of the social factors investigated, only unemployment was significantly related to occlusal wear. The sample area of the study, West Pomerania, suffers from a high unemployment rate. Thus, the prevalence rate of 43% of people who are or have been unemployed in the past is not surprisingly high; however, the relation to high occlusal wear (OR 1.6) was quite low.

Conclusion

Men show higher occlusal wear scores than do women. Bruxism is a considerable risk factor for high occlusal wear in men. Adverse occlusal situations, such as edgeto-edge or cusp-to-cusp situations or loss of natural occlusal support zones, are associated with high occlusal wear. Crowding and cross-bite are protective for high wear because they provide a more stable interocclusal contact pattern. In our study, nutrition habits did not show a visible influence on occlusal wear.

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