Associations Between Occupational Health Behaviors and Occupational Dental Erosion

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Abstract

Objectives: *The aim of this study was to evaluate the associations between occupational health behaviors and occupational dental erosion.* ***Methods:*** *Using data for 943 workers among 34 factories, selected by three-stage stratified cluster sampling from 888 factories using acids, two sets of modified case-control studies were performed. The cases were 242 workers with any dental erosion (G1-5) and 78 with severe dental erosion (G3-5); the controls were 701 workers with no erosion (G0) and 864 workers with no or mild erosion grades, G0-2, respectively. The main explanatory variables were behaviors such as wearing a respiratory mask and gargling at work. The results were adjusted for employment, age, sex, knowledge, and opinion about occupational health, attrition, and abrasion. Bivariate and multivariate logistic regression analyses were conducted.* ***Results:*** *The odds of overall occupational dental erosion (G1-5) was 0.63 (95% CI=0.42, 0.94) for respiratory mask wearers compared to nonwearers; the odds of severe occupational dental erosion (G3-5) was not significantly less in respiratory mask wearers (OR=0.94; 95% CI=0.53, 1.67). Gargling did not show a significant association with occupational dental erosion in this study.* ***Conclusions:*** *Among occupational health behaviors, wearing personal protective respiratory masks in work was significantly associated with less overall occupational dental erosion. [J Public Health Dent 2003;63(4):244-49]*

Key Words: occupational, dental erosion, behavior, wearing masks, gargling.

Occupational dental erosion is caused by exposure to various types of acidic contaminants in the workplace such as chemicals, petrochemicals, metals, and semiconductors (1-17). Severe dental erosion involving dentin is one of the statutory occupational diseases in Korea since 1994 (18,19). The prevalence of occupational dental erosion was 25 percent in Korea (2). Among those workers with dental erosion, 8 percent were affected by severe dental erosion involving dentin (2).

Every workplace is really a work environment where there are interactions between people and the chemical and physical demands involved with performing the job. Education about occupational hazards, positive opinion on the execution of a Worksite Oral Health Promotion (WOHP), and training for standardized behaviors such as wearing respiratory masks as personal protective equipments (PPE) and gargling during and/or after working time have been the most widely used measures to promote workers' health (20). To develop a WOHP program among factories using acids, the evidence that knowledge, opinion, and behaviors (KOBs) about occupational health can protect the occurrence and/or deterioration of occupational dental erosion should be shown.

To date, a question still exists regarding the association between occupational dental erosion and occupational health behaviors. The objective of this study was to evaluate associations between occupational health behaviors and occupational dental erosion.

Methods

To develop evidence-based occupational oral health policies and public health programs, a national epidemiologic study among Korean workers who were exposed to acid was conducted as a cross-sectional survey with the analysis designed as a case-control study using retrospective information. This analysis focused on two sets of modified case-control studies.

The required sample size was estimated at 1,000 under the condition of 10,000 total workers exposed to acids in registry, .05 of significant level, and sampling error of .03. Thirty-four factories were selected by three-stage stratified cluster sampling from among 888 factories known to use various types of acids such as hydrochloric acid, nitrous acid, and sulfuric acid. The first sampling stage was the type of industries (plating, galvanizing, chemical, dye, and petroleum), the second sampling stage was the number of employees in a factory (10–49, 50–99, and ≥100), and the final sampling stage was the region (Seoul industrial complex, Incheon industrial complex, Bupyung industrial complex, Ansan industrial complex, and Ulsan industrial complex). A unit of cluster was a factory. A total of 943 workers in 34 factories were selected, received an explanation of the study, provided written consent, and participated in this study.

One examiner conducted the examination for detecting noncarious dental hard tissue diseases such as dental erosion, dental abrasion, and dental attrition. The modified ten Cate's criteria (3) with six grades (G0-5) (Table 1) were used for dental erosion. The pathognomonic feature of dental abrasion is the presence of a wedge-shaped depression of tooth surface and that of dental attrition is usually a faceted area of tooth surface. Prior to the examination, all workers' tooth surfaces

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TABLE 1
Diagnostic Criteria for Erosion (Modified ten Cate's)

Severity Grade	Labial and Lingual Surface	Cervical Area*	Incisal Area and Occlusal Surface*
G0	Glossy enamel surface Incremental line	Glossy enamel surface	Glossy enamel surface
G1	Loss of groove Ground glass appearance	White yellowish spot	Irregular or clear tip White spot
G2	Loss of enamel surface Wave type depression	Crescent depression of enamel surface	Deep groove and ovoid depression of enamel surface
G3	Dentinal loss	Dentinal cupping	Dentinal cupping
G4	Dark brown secondary dentin was involved and incisal tip with attrition was chisel type	Dark brown secondary dentin was involved	Dark brown secondary dentin was involved
G5	Pulpal involvement	Pulpal involvement	Pulpal involvement

*Criteria for differential diagnosis of dental abrasion is the presence of wedge-type depression of tooth surface, and that of dental erosion is concave-type depression. Dental attrition and dental abrasion usually are accompanied by dental erosion.

TABLE 2
Prevalence Distributions of Occupational Dental Erosion by Categorical Variables and Severity of Dental Erosion

Variable (N=943)	Total Population	Overall Dental Erosion (G1-5) (%)	P-value*	Severe Dental Erosion (G3-5) (%)	P-value*
Knowledge†					
Aware	205	22.9	.365	7.8	.886
Unaware	733	26.3		8.3	
Opinion‡					
Positive	374	28.1	.195	8.8	.631
Negative	468	24.1		7.9	
Wearing masks¶					
Wearing	199	23.1	.313	9.5	.470
Nonwearing	686	27.0		8.0	
Gargling§					
Gargling	726	25.6	.929	8.1	.778
Nongargling	215	26.0		8.8	
Duration of employment					
3+ years	702	31.8	<.0001	10.3	<.0001
0–3 years	241	7.9		2.5	
Sex					
Male	831	26.6	.063	8.8	.144
Female	111	18.0		2.5	

*P-value based on chi-square tests.
†Knowledge: Are you aware that this occupation could incur occupational hazards?
‡Opinion: Do you agree with the execution of Worksite Oral Health Promotion?
¶Wearing masks: Are you wearing your personal respiratory masks?
§Gargling: Do you gargle during and/or after working time?

were wiped with a dry cotton pellet. The examination was conducted under natural light with an explorer. Dental erosion, dental abrasion, and dental attrition were recorded by tooth rather than by surface in this study. When a tooth exhibited more than one type of distinct condition, both conditions were recorded. To evaluate the reliability of the examination, 79 workers were reexamined in one-half hour intervals. The intraexaminer reliability using this diagnostic criteria was a kappa index of 0.9.

The outcome variable for this study was dental erosion, which was recorded by grade. For this study, dental erosion was classified into two different patterns by severity: normal (G0) versus overall occupational dental erosion (G1-5) (overall erosion), and

TABLE 3
Mean Value (SD) of Continuous Variables by Severity of Dental Erosion and Workers with/without Occupational Dental Erosion

	Overall Dental Erosion (G1-5)			Severe Dental Erosion (G3-5)		
Variable	Workers with Erosion (*N*=242) Mean (SD)	Workers without Erosion (*N*=701) Mean (SD)	*P*-value*	Workers with Erosion (*N*=78) Mean (SD)	Workers without Erosion (*N*=864) Mean (SD)	*P*-value*
Age	37.1 (9.10)	33.3 (9.5)	.0001†	40.2 (10.0)	33.3 (9.3)	.0001†
Teeth with attrition	2.4 (4.09)	1.08 (2.40)	.0001	2.79 (4.66)	1.30 (2.75)	.007
Teeth with abrasion	1.54 (2.69)	1.01 (2.47)	.008	2.19 (3.31)	1.05 (2.44)	.004

*P-value from *T*-test comparison of means.
†Variances equal.

normal or mild erosion (G0-3) versus severe occupational erosion (G 3-5) (severe erosion). The cases were 242 workers with overall dental erosion (G1-5) and 78 workers with severe dental erosion (G3-5); the controls were 701 workers with no erosion (G0) and 864 workers with no or mild erosion (G0-2), respectively.

KOBs (Table 2) included knowledge about occupational hazards, positive opinion on the execution of a WOHP, and behaviors such as wearing respiratory masks as personal protective equipments (PPE) (wearing masks), and gargling during and/or after work. The information about KOBs was obtained by using pretested questionnaires and personal records in the factories. Self-reported questionnaires were administered just prior to the dental examination. The main explanatory variables were behaviors such as wearing masks and gargling. Knowledge and opinion were considered potential confounders of reported behaviors. Other variables analyzed were dental attrition, dental abrasion, length of job exposed to acids, age, and sex as potential confounder variables of occupational dental erosion (21).

Bivariate associations were assessed by chi-square tests or Student's *T*-tests. Multivariate logistic regression analysis was performed to compute adjusted odds ratio (OR) estimates. For each main explanatory variable, negative response was made the reference category. For other categorical variables, the category with the lowest prevalence of dental erosion was selected as the reference group. Interaction terms also were assessed. For the final model, the change of –2 log likelihood and 10 percent change of OR was assessed during multiple logistic regression modeling. The level of statistical significance for main effects and the power were set at .05 and .8, respectively.

Results

Among 943 workers exposed to acids, 21.9 percent were aware of occupational hazards, 39.7 percent approved the execution of Worksite Oral Health Promotion, 22.5 percent wore personal respiratory masks, and 77.2 percent gargled during or after work. Although all 34 factories had kept the guideline of threshold limit values (TLVs) of various acids according to the records of the annual inspection of work environment, the prevalence of occupational dental erosion (G1-5) was 25.6 percent and that of severe occupational dental erosion (G3-5) was 8 percent. Age was approximately normally distributed, and ranged from 15 to 63 years with a mean of 34.3 years (SE=0.31). The number of teeth with dental attrition ranged from 0 to 28, with a mean of 1.43 (SD=3.0). The number of teeth with dental abrasion ranged from 0 to 21, with a mean of 1.15 (SD=2.55).

Tables 2 and 3 show the results of the bivariate analyses for the categorical and continuous variables, respectively. Workers with knowledge of occupational hazards and workers who wore a mask did not have the lower prevalence of occupational dental erosion (G1-5). The prevalence of severe occupational dental erosion (G3-5) was not lower for workers with knowledge or workers who gargled during and/or after work. Therefore, knowledge, opinion, wearing masks and gargling were not associated with overall erosion and severe erosion in bivariate analyses. Only length of employment was associated with overall erosion and severe erosion in bivariate analysis. Workers exposed to acids for three years or longer had a higher prevalence of overall erosion and severe erosion than workers exposed for less then three years. The mean age for the workers with overall erosion was 3.8 years higher than for workers without erosion, and it was 6.4 years higher for the workers with severe erosion than for workers without severe erosion. The mean number of teeth with attrition was more than twice as high among cases than among controls for both case-control analyses. The mean number of teeth with abrasion was the same for cases and controls.

Wearing masks, gargling, knowledge of occupational hazards, opinion about worksite health promotion, length of employment, age, sex, attrition, and abrasion were entered into a multiple logistic regression model. No interaction terms among explanatory variables were found significant in this analysis. Table 4 shows that respiratory mask wearers were less likely than nonwearers to have teeth with erosion (G1-5). The adjusted odds ratio of 0.63 (95% CI=0.42, 0.94) for respiratory mask wearers was significantly changed from the crude odds ratio of 0.81 (95% CI=0.56, 1.18) in overall erosion. For severe erosion (G3-5), an adjustment for potential

TABLE 4
Crude and Adjusted Odd Ratios for Behaviors in Final Multiple Logistic Regression Model, by Severity of Occupational Dental Erosion

Outcome Variable	Explanatory Variable	Odds Ratio (95% Confidence Interval)		P-value
		Crude	Adjusted	
Overal dental erosion (G1-5)‡	Wearing masks			
	Wearing	0.81 (0.56, 1.18)	0.63 (0.42, 0.94)	.024
	Nonwearing¶	1.0	1.0	—
	Gargling			
	Gargling	0.98 (0.69, 1.38)	0.94 (0.64, 1.39)	.759
	Nongargling¶	1.0	1.0	—
Severe dental erosion (G3-5)§	Wearing Masks			
	Wearing	1.21 (0.70, 2.09)	0.94 (0.53, 1.78)	.826
	Nonwearing¶	1.0	1.0	—
	Gargling			
	Gargling	0.91 (0.53, 1.57)	0.97 (0.53, 1.78)	.928
	Nongargling¶	1.0	1.0	—

*Adjusted for knowledge, opinion, age, sex, length of job, dental attrition, dental abrasion, and mutually.
†P-value from Wald chi-square statistic.
‡N=877, model chi-square=97.08, df=9, P=.000, –2 log likelihood=910.10, adjusted R^2=0.15, overall predictability=73.9.
¶Reference category.
§N=877, model chi-square=46.37, df=9, P=.000, –2 log likelihood=461.12, adjusted R^2=0.12, overall predictability=91.7.

confounders did not significantly change the crude odds ratio of wearing a mask or gargling. Although gargling did not show any significant association with any type of occupational dental erosion in this study, wearing personal protective respiratory masks in work was significantly associated with overall occupational dental erosion.

Discussion

Dental erosion is an increasingly important dental hard tissue condition that may well be as important as dental caries in 21st century Europe (22). In Korea, dental erosion, the most conspicuous occupational hazard, has been highlighted socially since 1992 because this tooth surface condition is socially problematical.

In occupational epidemiology, a commonly used approach is to conduct a case-control study nested within an occupational cohort. The retrospective information on occupational behaviors may have changed since the time of being exposed to acid. Hence, the retrospective timing of the information was earlier than the present timing of active dental erosion. The sample size of nearly 1,000 subjects was adequate to permit adjustment for potential confounders by multivariate analysis.

TLVs have been used for guidelines on safe working environments in many countries, including Korea and the United States. However, dental erosion can occur within a short time period in the workplace even when acid concentrations are below the recommended standard (23). The minimum exposure time of a worker with tooth erosion was four months; the estimated average acid exposure was 0.23 mg/m^3 sulfuric acid, for which the TLV is 1.0 mg/m^3 (23). Although 34 factories had kept the guideline of TLVs for acids, the prevalence of occupational dental erosion was not low and many workers had statutory occupational dental erosion (G3-5). TLVs possibly should be lowered, if the National Institute of Occupational Safety and Health (NIOSH) considers the tooth a risk organ. It is difficult to reduce the recommended standard to the critical level at which there is no risk to human organs including teeth because it would be expensive. Therefore, alternative protection program such as WOHP should be implemented.

This study had some limitations common to case-control studies. For the more strict analysis of risk and preventive factors for occupational dental erosion, a longitudinal study including various other factors such as lifestyle and systemic health status would be needed, because dental erosion can be attributable to other causes. Despite the limitations of this study, the results are sufficient to evaluate the association of wearing masks and gargling with occupational dental erosion.

Dental erosion begins with subtle changes in the surface enamel and can progress to severe loss of tooth substance (24). Although early diagnosis may be difficult, it is important to detect dental erosion as soon as possible (25). Many reports indicate that a valid and reliable diagnosis of dental erosion is not easy (4,8,13,26). Sometimes dental erosion was accompanied by dental attrition (2-5). As to the diagnostic criteria used in this study, the criteria had indices for occlusal and cervical surface of teeth comparable to ten Cate's criteria (3).

The modified Tooth Wear Index (TWI) was used in the national oral health survey in the United Kingdom (24). Although Smith and Knight insisted that the TWI index was an efficient and practical way of recording degrees of tooth wear without making a diagnosis of its cause (24), it was believed that there were difficulties in

making reliable diagnosis of dental erosion using the TWI index. The limitation of the TWI index is that the ambiguous term "tooth wear" is much less appropriate than the clear terms "dental erosion," "dental abrasion," and "dental attrition." Hence, using the TWI index, it is not possible to determine the etiology of dental erosion, dental abrasion, or dental attrition. To prevent dental erosion and to make a clinical differential diagnosis between dental erosion, dental abrasion, and dental attrition, pathognomonic features are critical. In these points, the criteria used in this study were more appropriate. Moreover, a kappa coefficient of 0.9 for dental erosion showed that it was a reliable index. Additional studies need to be conducted using these criteria in different populations.

Traditionally, wearing masks as personal protective equipment (PPE) was the most common recommendation for protection from the hazardous environment (27). This study showed that the odds of overall occupational dental erosion was 0.63 times less for workers wearing respiratory masks than for workers not wearing masks. It also showed the limitation of wearing masks, i.e., wearing masks was not effective for preventing severe occupational dental erosion. For the prevention of severe occupational dental erosion, the reduction of the ambient acid level is the measure of choice. PPE such as respiratory masks can be used for short-term operations where engineering controls may be a very expensive alternative. Hence, these results of this study support the general paradigm that PPE such as respiratory mask can be used as a final line of defense for protecting the employee against potentially harmful conditions in the work environment (27).

Gargling has been a routine program of a worksite health promotion (20). The results of this study found that it was not associated with occupational dental erosion. Although mouthrinsing could be thought to reduce the acidity in an oral cavity that caused the dental erosion in general, the results of this study indicated that it did not protect against inhalation of the harmful acidic airborne material.

In evaluating the associations of behaviors, wearing masks actually reduced the risk of overall occupational dental erosion. Because PPE such as respiratory masks could be uncomfortable, the results showed that around 80 percent of workers avoided their use (Table 2). If workers do not understand the reasons for using a mask, they are likely to misuse the devices and consequently do not receive the necessary protection. Workers' acceptance is a salient factor for the successful use of PPE. It was no surprise that behavioral change was the most important factor in KAP models (28). Although knowledge had no association with occupational dental erosion in this study, it should be remembered that the utility of knowledge is necessary, but not sufficient to facilitate behavior change (29). The finding that more workers supported the execution of WOHP if they had occupational dental erosion than if they did not showed that the injuries by occupational dental erosion taught the workers the need for WOHP. This positive opinion on WOHP will increase one's belief in ability to perform the behavior (28).

In many countries, occupational hazards are the responsibility of managers and owners of factories who would be held liable for the resulting harm. The design of the factory environment and working practice are more important than the individual worker's knowledge and behavior. In this context, it would have been more useful to identify knowledge and opinions among those with responsibility for worksite practices and environment.

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