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Active and passive smoking and prevalence of periodontal disease in young Japanese women

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Background and Objective: Studies reporting on the association between smoking and periodontal disease have mostly focused on active smoking. The purpose of this study was to examine the relationships between active smoking and exposure to second-hand smoke at home and at work and the prevalence of periodontal disease among young Japanese women.

Material and methods: Study subjects were 1167 postpartum women with a mean age of 31.5 years. Information on smoking and potential confounding factors was obtained through a self-administered questionnaire. Partial-mouth recording was used to determine probing pocket depth at six sites per tooth for six teeth in the mouth. Periodontal disease was defined as positive if a woman had at least one tooth with a probing pocket depth of 3.5 mm or deeper. Adjustment was made for age, region of residence, household income, education, toothbrushing frequency and use of an interdental brush.

Results: Compared with never smoking, ever smoking was independently positively associated with the prevalence of periodontal disease: the adjusted odds ratio was 1.56 (95% confidence interval: 1.02–2.36). There was a marginally significant positive dose–response relationship between pack-years of smoking and the prevalence of periodontal disease (p for linear trend = 0.08). No material associations were observed between second-hand smoke exposure at home or at work and periodontal disease.

Conclusion: Our findings suggest that active smoking, but not passive smoking, might be associated with an increased prevalence of periodontal disease among young women in Japan.

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Periodontal disease is a chronic condition characterized by inflammation of the supporting tissues of the teeth. A complex relationship among bacterial, host, behavioral and environmental factors determines the development and progress of the disease (1). A number of epidemiological studies have reported the deleterious effects of smoking on periodontal health (2–13). A 4-year longitudinal study showed a dose–response relationship between the amount of smoking and the incidence of periodontal disease among Japanese men, 30–59 years of age (2). Do *et al.* showed, using nationally representative cross-sectional data from the 2004–2006 Australian National Survey of Adult Oral Health, that former and current smokers had significantly higher rates of periodontal disease compared with never smokers (3). A systematic review concluded that there was strong evidence to suggest that smoking negatively interferes with periodontal health (14). Epidemiological

data on the association between smoking and periodontal disease in young adults are limited, however. In order to reach a clear conclusion about this association in young adults, it is important to accumulate additional epidemiological evidence.

Most previous studies on the association between smoking and periodontal disease have focused on active smoking. In contrast, little is known about the relationship between secondhand smoke (SHS) exposure and periodontal disease. To our knowledge, only four epidemiological studies have addressed this relationship in adults and all observed a significant, positive association of SHS exposure with periodontal disease (15–18). SHS exposure is likely to be associated with periodontal disease as is active smoking. Further evidence is needed to clarify the influence of SHS exposure on periodontal disease. A recent systematic review regarding the association between active and passive smoking and periodontal disease suggested that SHS exposure may be associated with an increased prevalence of periodontitis and an increased risk for periodontitis progression (19).

In the present study, we assessed the relationships between active smoking and SHS exposure at home and at work and the prevalence of periodontal disease among young Japanese women, using the data set of the Kyushu Okinawa Maternal and Child Health Study (KOMCHS).

Material and methods

Study population

The KOMCHS is an ongoing prospective prebirth cohort study that investigates risk and preventive factors for maternal and child health problems such as oral health and allergic disorders. The background and general procedure of the KOMCHS have been described previously (20,21). In brief, the KOMCHS requested that pregnant women complete a baseline survey, which was followed by several postnatal surveys. Eligible subjects were those women who became pregnant in one of seven prefectures on Kyushu Island in southern Japan or in Okinawa Prefecture between April 2007 and March 2008. At 423 obstetric hospitals, a set of leaflets explaining the KOMCHS, an application form to participate in the study and a self-addressed and stamped return envelope were distributed to pregnant women, insofar as this was possible. Pregnant women who intended to participate in the KOMCHS returned the application form to the data-management center. In the end, a total of 1757 pregnant women between the 5th and 39th weeks of pregnancy gave their fully informed consent in writing to participate and completed the baseline survey. Of these 1757 women, 1591 mothers participated in the second survey after birth. Of these 1591 mothers, 1177 women received oral examinations between 1 and 12 mo postpartum. Ten women were excluded because of missing data on the factors under study, leaving data on 1167 pregnant women available for analysis. The ethics committee of the Faculty of Medicine, Fukuoka University, approved the KOMCHS.

Outcome variable

Oral examinations for periodontal tissue condition between 1 and 12 mo postpartum were performed by dental hygienists. Probing pocket depth was determined using a community periodontal index probe (YDM Corp., Tokyo, Japan) at six sites per tooth for six teeth: the right first molar, the right first incisor and the left first molar in the maxilla; and the right first molar, the left first incisor and the left first molar in the mandible. The deepest probing pocket depth was recorded for each tooth. Periodontal disease was defined as positive if a woman had at least one tooth with a probing pocket depth of 3.5 mm or deeper.

Exposure variables and covariates

The baseline survey consisted of a set of two self-administered questionnaires. Participants mailed the answered questionnaires to the data-management center. Research technicians completed missing or illogical data by telephone interview.

The questionnaire in the baseline survey included questions about smoking habits, SHS exposure at home and at work, household income, education, toothbrushing frequency and use of an interdental brush.

Statistical analysis

Age, region of residence, household income, education, toothbrushing frequency and use of an interdental brush were a priori selected as potential confounding factors. Region of residence was classified into three categories (Fukuoka Prefecture; other than Fukuoka Prefecture on Kyushu Island; and Okinawa Prefecture), household income was classified into three categories ($< 4{,}000{,}000$, 4,000,000–5,999,999 and $\geq 6{,}000{,}000$ yen/year), education was classified into three categories (< 13, 13–14 and ≥ 15 years), toothbrushing frequency was classified into three categories (< 2, 2 and ≥ 2 times/d), use of an interdental brush was classified into two categories (no and yes), active smoking was classified into two categories (never and ever), pack-years of smoking was classified into three categories (none, 0.05–3.9 and ≥ 4.0), SHS exposure at home was classified into two categories (never and ever) and SHS exposure at work was classified into two categories (never and ever). Age was used as a continuous variable.

Logistic regression analysis was performed to estimate crude odds ratios and their 95% confidence intervals for periodontal disease in relation to smoking status. Multiple logistic regression analysis was employed to adjust for potential confounding factors. Trend of association was assessed using a logistic regression model assigning consecutive integers to the categories of the exposure variables. Two-sided p-values of less than 0.05 were considered statistically significant. All statistical analyses were performed using the SAS software package version 9.2 (SAS Institute, Inc., Cary, NC, USA).

Results

The prevalence of periodontal disease among the 1167 pregnant women was 11.3%. Characteristics of the study subjects are described in Table 1. The mean age of the participants was 31.5 years. Toothbrushing two and three or more times per day was reported for 50.6% and 36.7% of study participants, respectively. An interdental brush was used by about 46% of the women.

Table 2 shows crude and adjusted odds ratios and their 95% confidence intervals for periodontal disease in relation to active smoking status. There were no statistically significant associations between active smoking or pack-years of smoking and the prevalence of periodontal disease in the univariate model. Nevertheless, after adjustment for age, region of residence, household income, education, toothbrushing frequency and use of an interdental brush, compared with never smoking, ever smoking was independently positively associated with the prevalence of periodontal disease: the adjusted odds ratio was 1.56 (95% confidence interval: 1.02–2.36). In the multivariate model, a positive dose–response relationship between pack-years of smoking and periodontal disease was of borderline significance (p for linear trend = 0.08).

Table 1. Distribution of selected characteristics in 1167 women, Kyushu Okinawa Maternal and Child Health Study, Japan

Variable	Value
Age (years)	31.5 ± 4.2
Region of residence	
Fukuoka Prefecture	741 (63.5)
Other than Fukuoka Prefecturein Kyushu	318 (27.3)
Okinawa Prefecture	108 (9.3)
Household income (yen/year)	
< 4,000,000	379 (32.5)
4,000,000–5,999,999	419 (35.9)
≥ 6,000,000	369 (31.6)
Education (years)	
< 13	243 (20.8)
13–14	387 (33.2)
≥ 15	537 (46.0)
Toothbrushing frequency (times/d)	
< 2	149 (12.8)
2	590 (50.6)
≥ 3	428 (36.7)
Use of an interdental brush	
No	631 (54.1)
Yes	536 (45.9)

Values are given as mean ± standard deviation or *n* (%).

Table 2. Adjusted odds ratios (ORs) and their 95% confidence intervals (95% CIs) for periodontal disease according to active smoking status in 1167 pregnant women (the data set used was that of the Kyushu Okinawa Maternal and Child Health Study, Japan)

	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)[a]
Active smoking			
Never	88/824 (10.7)	1.00	1.00
Ever	44/343 (12.8)	1.23 (0.83–1.80)	1.56 (1.02–2.36)
Pack-years of smoking			
None	88/824 (10.7)	1.00	1.00
0.05–3.9	23/166 (13.9)	1.35 (0.81–2.17)	1.69 (0.98–2.82)
≥ 4.0	21/177 (11.9)	1.13 (0.66–1.84)	1.44 (0.82–2.46)
p for trend		0.44	0.08

[a]Adjustment for age, region of residence, household income, education, toothbrushing frequency, and use of an interdental brush.

Table 3 shows the association between SHS exposure and periodontal disease among the 824 subjects who had never smoked. There were no material associations between SHS exposure at home or at work and the prevalence of periodontal disease, regardless of adjustment for potential confounding factors.

Discussion

In this study, we found that active smoking was significantly positively associated with the prevalence of periodontal disease. On the other hand, there was no relationship between SHS exposure and the prevalence of periodontal disease. Our results are consistent with those of previous studies that reported a positive association between active smoking and periodontal disease (2–11). A cross-sectional study using a national database in Japan showed that, compared with nonsmoking, current smoking, but not former smoking, was associated with an increased prevalence of periodontal disease in adults older than 40 years of age (4). Among adolescents and young adults in south Brazil, heavy smoking (1500 or more packs of cigarettes in a lifetime) was significantly associated with chronic periodontitis (6).

Smoking is a well-established risk factor for periodontitis (22,23). The biological mechanisms of periodontal disease are characterized by an imbalance between bacterial virulence and host-defense activity (24). The most plausible mechanism that explains the relationship between smoking and periodontal disease is that smoking interacts with host cells and affects inflammatory responses to microbial challenge (22). Tobacco smoking might modulate the destruction of the

Table 3. Adjusted odds ratios (ORs) and their 95% confidence intervals (95% CIs) for periodontal disease according to passive smoking status in 824 pregnant women who had never smoked (the data set used was that of the Kyushu Okinawa Maternal and Child Health Study, Japan)

	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)[a]
Passive smoking at home			
Never	31/241 (12.9)	1.00	1.00
Ever	57/583 (9.8)	0.73 (0.46–1.18)	0.66 (0.40–1.10)
Passive smoking at work			
Never	40/336 (11.9)	1.00	1.00
Ever	48/488 (9.8)	0.81 (0.52–1.26)	0.66 (0.41–1.08)

[a]Adjustment for age, region of residence, household income, education, toothbrushing frequency and use of an interdental brush.

periodontal tissue through various pathways: microcirculatory and host immune systems; connective tissue; and bone metabolism (24).

In contrast to the many reports regarding the relationship between active smoking and periodontal disease, epidemiologic information regarding the association between SHS exposure and periodontal disease is scarce (15–18). A cross-sectional study of 2739 nonsmokers, 53–74 years of age, in the USA demonstrated that, compared with less than 1 h/wk of SHS exposure, 26 h/wk or more of SHS exposure was significantly positively associated with periodontal disease (15). In a cross-sectional study among 256 Japanese workers, 18–62 years of age, a significant, positive association was observed between passive smoking, as determined by salivary cotinine level (1–7 ng/mL), and the prevalence of periodontal disease (16). A study using the data from the Third National Health and Nutrition Examination Survey found that the odds of having periodontal disease were 1.6 times greater for persons exposed to SHS than for persons not exposed to SHS in 6611 persons 18 years of age and older who had never smoked (17). These results are at variance with our findings that show no association between SHS exposure and periodontal disease. It should be noted that the studies mentioned here used different definitions of outcome, study populations, SHS exposure assessment methods and confounding factors, thus limiting the feasibility of inter-study comparisons. In Japan, a law that restricts smoking in public places came into effect in 2004. Since then, awareness of the effects of environmental tobacco smoke has increased, and many workplaces now have smoking restrictions or bans. In recent years, exposure to SHS at work has probably become less common.

This study had certain methodological strengths. The study subjects were homogeneous in that all were young women, which probably reduces the potential for confounding resulting from unmeasured factors. In the present study, oral examinations were performed between 1 and 12 mo postpartum (66% took place between 3 and 5 mo postpartum). During pregnancy, susceptibility to periodontal infection increases as a result of immunological and hormonal changes (25). Pregnancy-related changes are most frequent and most marked in gingival tissue. However, these gingival changes usually resolve within a few months of delivery (26). Thus, our study subjects are unlikely to be unduly affected by pregnancy.

We were able to control for relevant confounding factors. However, it is possible that our results remain confounded by other potentially important factors, such as patterns of dental visits and alcohol consumption.

Several limitations of this study have to be taken into account. The participation rate could not be calculated because the exact number of eligible pregnant women who were provided with a set of leaflets explaining the KOMCHS, an application form, and a self-addressed and stamped return envelope by the 423 collaborating obstetric hospitals is not available. We were not able to assess the differences between participants and nonparticipants because information on personal characteristics, such as age and socio-economic status, among nonparticipants was not available. Our subjects were probably not a representative sample of Japanese women in the general population. In fact, educational levels in the current study population were higher than in the general population. According to the 2000 population census of Japan, the proportions of women 30–34 years of age in Fukuoka Prefecture with < 13, 13–14, ≥ 15 and an unknown number of years of education were 52.0%, 31.5%, 11.8% and 4.8%, respectively (27). The corresponding figures for the current study were 20.8%, 33.2%, 46.0% and 0.0%, respectively. In addition, according to the National Survey of Dental Disease conducted in 2005 (28), the prevalence of periodontal disease, defined as one or more periodontal sites with a probing pocket depth of 4 mm or deeper, was 23.9% in their sample of persons 30–34 years of age, while only 11.3% of our study subjects had periodontal disease. The present population might therefore have had a greater awareness about health than the general population. Nevertheless, cigarette-smoking status in our study population was likely to have been similar to that in the general population. In the National Health and Nutrition Survey in Japan in 2007 (29), the percentages of ever-smoking and never-smoking women, 30–39 years of age, were 28.6% and 71.4%, respectively. The corresponding figures for the subjects in the present study were 29.4% and 70.6%, respectively.

In the present study, oral examinations were performed by dental hygienists. The dental hygienists were given detailed criteria for performing the examinations, but they received no specific training aimed at standardizing the procedures. In addition, no reliability assessment of measurements was carried out in the present study. Therefore, it is unknown whether intra-examiner and interexaminer consistency were established.

Other limitations may also have influenced the interpretation of the current results. Because partial-mouth recording was used in the present study, the prevalence of periodontal disease might have been underestimated. It has been demonstrated, however, that using half-mouth as opposed to full-mouth data collection is unlikely to affect the outcome of analytic studies among young adults (30). Moreover, our case definition of periodontal disease was based solely on the measurement of probing pocket depth, that is, the distance from the gingival margin to the base of the gingival sulcus or periodontal pocket. Measurements of probing pocket depth and clinical attachment level correlate well in many groups, especially younger populations, and both are accepted as measures of periodontal status (31).

Assessment of exposure was based on the subjects' questionnaire responses and was not validated by objective measurements, such as salivary, serum or hair cotinine levels or exhaled carbon monoxide level. Using

questionnaires may result in misclassification as a result of recall bias. In the present study, information on smoking exposure was collected during pregnancy. Some subjects might have deliberately concealed their tobacco smoking during pregnancy in order to give a socially desirable response. If present, however, this bias would tend to reduce the observed association between smoking and periodontal disease. We did not measure SHS exposure in social settings outside the home and work. Data on the number of cigarettes involved in passive smoking were not available. Given the difficulties of accurately measuring SHS exposure, the association between SHS exposure and periodontal disease observed here is likely to be an underestimate.

Conclusions

We confirm a positive association between active smoking and periodontal disease among young adult women in Japan. This is consistent with results from previous studies, further strengthening the notion that active smoking is associated with an increase in the risk of periodontal disease. On the other hand, the results of the present study failed to substantiate a positive association between SHS exposure and periodontal disease. As the accumulation of additional evidence regarding the relationship between SHS exposure and periodontal disease is expected to be an important step in clarifying whether SHS exposure is a risk factor for periodontal disease, further investigations are needed.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

KT, YM, and MA contributed to the study concept and design and the acquisition of data. TH contributed to the dental survey. KT was responsible for the analysis and interpretation of data and the drafting of the manuscript.

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