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Relationship of smoking and smoking cessation with oral health status in Japanese men

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Background and Objective: Smoking has been associated with the number of natural teeth a person has and with the likelihood of periodontitis. The purpose of this study was to determine the relationships between the number of teeth present and periodontal diseases with smoking habits in a cohort of Japanese men.

Material and Methods: The study group comprised 1088 men, 40–75 years of age. Oral examinations were conducted in dental clinics. Information on smoking status and on oral health behavior was collected from self-administered questionnaires. The relationship between oral health status and smoking status was estimated using adjusted odds ratios.

Results: Compared with those whom had never smoked, the odds ratios of having more than eight missing teeth and having periodontitis, among current smokers, were 1.67 and 1.74, respectively. In those who had stopped smoking for 11 years or longer, there was no increase in the odds ratio of having more than eight missing teeth and periodontitis, compared with those whom had never smoked.

Conclusion: Smoking has a positive association with missing teeth and periodontitis. However, smoking cessation is beneficial for oral health. The odds of having more than eight missing teeth, or of having periodontitis, in those who had never smoked was similar to that of individuals who reported that they had stopped smoking for 11 years or more.

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Tooth loss affects the daily activities of humans, such as speaking, smiling, chewing and tasting; therefore, toothloss prevention helps to maintain a high quality of life. Previous studies have reported that smoking is associated with tooth loss, a higher prevalence of edentulousness and fewer remaining teeth (1–6). The main biological causes of tooth loss are periodontal disease and dental caries (7). A complex relationship among bacterial, host, behavioral and environmental factors determines the onset and progress of these oral diseases. Smoking is an important risk factor for periodontal disease (8–13) and a clear causal association has been established (14). Promoting smoking cessation on the advice of dental professionals may therefore be an effective tool in preventing periodontal disease and tooth loss in smokers.

Smoking has major effects on the host response, but there are also a number of studies that show some microbiological differences between smokers and nonsmokers. The biological mechanisms underpinning the adverse effects of smoking have been comprehensively reviewed by Palmer *et al.* (15).

However, in Japan, few epidemiological studies have investigated the relationship between smoking cessation and the risk of tooth loss and periodontal diseases (16–18). Similarly, there are few studies on dental diseases that have assessed the length of smoking cessation required to gain measurable oral health benefits (19,20). It has been reported that smoking cessation decreases the risk of certain diseases, and in some cases reduces the risk to the same level as in neversmokers. The risk of lung cancer in men, for example, returns to the level found in never-smokers 30 years after quitting smoking among light smokers (i.e. fewer than 10 cigarettes per day) and more than 40 years after quitting among heavy smokers (21). The risk of coronary heart disease decreases within 2 years of smoking cessation (22); and approximately 15 years after smoking cessation, the mortality rates from coronary artery disease and stroke among former smokers approach the level found in neversmokers (23).

The central aim of this study was to investigate whether we could explain variation in the length of smokingcessation years regarding oral health gain in the same manner as in general health studies. The purpose of this study therefore was to investigate the relationship between smoking and smoking cessation with the number of teeth present and periodontal status.

Material and methods

Subjects

This study was designed to investigate the relationship between general lifestyle and oral health status, and was conducted in co-operation with the Akita prefecture local government, whose advice was followed. The subjects in the present study were residents in Yokote city, Akita prefecture. In this district, about 33,000 residents were 40-75 years of age. Subjects were recruited by letter to participate in this study. All 33,000 residents were included in the sampling. Some 2681 participants agreed to join the study and signed the informed consent form in 2005 to 2007. Self-administered questionnaires were given to participants, and dental examinations were conducted at local dental offices with the co-operation of the Yokote and Hiraka Dental Associations. Subjects were given a list of participating dentists and were free to attend the office of their choice that was closest to their residence.

Dental examination

Clinical examinations for dental status and periodontal tissue condition (third molars were excluded) were performed by local dentists who were provided with special information and training specific to this study. Training consisted of circulating a manual of the constituents and standards for conducting dental examinations and having a meeting with dentists to explain the procedures and to answer any concerns. Subjects were dentally examined in a dental chair using an operatory light, a dental mirror, a periodontal probe and an explorer, which were routinely used in the dental clinic of each participating dentist. Probing pocket depth was measured at all sites for all natural teeth. The deepest pocket depth was recorded for each tooth, excluding third molars. Periodontitis was defined as an individual having 'at least one tooth with severe pocket depth, i.e. pocket depth of 6 mm or greater'. The World Health Organization, in the Community Periodontal Index (CPI) definition for code 4, describes a pocket depth of 6 mm or more as 'severe periodontitis'. No inter-reliability or intrareliability tests were carried out.

Self-reported questionnaire

Prior to the clinical examination, the participants were asked to complete a self-reported questionnaire regarding their smoking habits and oral health behavior. Information collected on smoking habits included participants' current smoking status, the number of cigarettes smoked per day and the age when subjects either commenced or quit smoking. Smoking status was categorized into three groups: 'never smoked'; 'current smokers'; and 'former smokers'. The number of cigarettes per day was calculated for current smokers and former smokers, and the smoking-cessation years were calculated for former smokers. For current smokers, the level of smoking exposure was categorized into three groups depending upon the number of cigarettes (\leq 15, 16–20, or \geq 21) smoked per day. For former smokers, smoking exposure was categorized in the same way, that is, number of cigarettes (≤ 15 , 16–20, or ≥ 21) previously smoked per day. Smokingcessation years were categorized into four groups depending on time since stopping (≤ 10 , 11–20, 21–30, or ≥ 31 years).

Information regarding oral health behavior included the following: frequency of daily toothbrushing; using dental floss or an interdental brush; experience of toothbrushing instruction; self-check of teeth and gums using a mirror; and whether subjects had undergone a dental check-up within the previous 12 mo. Frequency of daily toothbrushing was categorized as 'twice or more', or 'less than twice'; other variables were all 'yes' or 'no' responses.

The percentages of current smokers and former smokers among female subjects were only 4.6% and 2.6%, respectively. This number was considered to be too low for statistical analysis. and thus female subjects were excluded. Subjects with missing covariate information were also excluded, resulting in a total of 1088 men who were used in the final analysis. Thirty subjects were edentulous and were excluded from the analyses on periodontal diseases. All variables analyzed in this study were part of a single database. This survey was approved by the Ethics Committee of Tokyo Medical and Dental University, Tokyo, Japan.

Statistical analysis

The chi-square test and the *t*-test were used to detect statistical differences in the distribution of the number of teeth present and the periodontal status. Negative binomial regression was used to calculate adjusted mean numbers of teeth present, by controlling for age and oral health behavior according to smoking status, the number of cigarettes per day and smoking-cessation years.

The 8020 Campaign is a national oral health campaign in Japan, jointly proposed by the Ministry of Health and Welfare and the Japanese Dental Association. The '80' signifies the average life expectancy for Japanese people, and the '20' indicates the critical number of natural teeth needed to maintain good eating and chewing function throughout life (24,25). In the analyses in this study, dependent variables were dichotomized in terms of the 8020 aspirations. That is, subjects were classified into two categories in terms of whether (i) they had more than eight missing teeth (i.e. retained fewer than 20 teeth) or (ii) they had eight or fewer missing teeth (i.e. they retained 20 or more teeth, in line with the current 8020 goal).

With respect to periodontal status, subjects were also classified into two groups, namely (i) those with periodontitis (one or more teeth with a pocket depth of 6 mm or more) or (ii) no periodontitis (no teeth with a pocket depth of 6 mm or more). Logistic regression was used to obtain adjusted odds ratios (ORs) and 95% confidence intervals (CIs), which were then used to examine the associations between 'having more than eight missing teeth' and smoking status, and between those classed as with/without periodontal disease and smoking status. These categories appear to be consistent with the findings and suggestion of previous reports (26,27).

Statistical adjustments were made for age and oral health behavior as previous studies had reported a positive association between these factors and tooth loss and periodontal diseases (28,29). Two-sided *p*-values of < 0.05 were considered to be statistically significant. spss 16.0J (SPSS Japan, Tokyo, Japan) was used to analyze the data.

Results

Distribution of smoking status

From the questionnaire survey, 317 subjects (29.1%) responded that they were 'current smokers', 421 (38.7%) that they were 'former smokers' and 350 (32.2%) stated that they had 'never smoked'.

Characteristics categorized by number of teeth present and periodontal status

The age of the subjects ranged from 40 to 75 years (mean = 59.6, standard

deviation = 9.7). The mean age, categorized by the number of teeth present, was 65.8 \pm 7.6 years for subjects with 0-19 teeth (i.e. more than eight missing teeth) and 57.3 \pm 9.3 years for subjects with 20-28 teeth (i.e. eight or fewer missing teeth). The difference between the two groups was statistically significant (p < 0.001). The mean age, categorized according to the periodontal status, was 60.7 \pm 9.3 years for those with periodontitis and 59.2 \pm 9.8 years for those without periodontitis. The difference between the two groups was statistically significant (p = 0.024). When age was grouped by decade from 40 years upwards (40-49, 50-59, 60-69, 70-75), the relationship between age and 20 or more teeth was retained, but the relationship with periodontitis did not reach statistical significance, although a trend was evident.

Table 1 shows the distributions by age group and oral health behavior and by the number of teeth present and periodontal status. Subjects with more than eight missing teeth were older (p < 0.001), had a lower frequency of daily toothbrushing (p < 0.001), a lower prevalence of using interdental brushing tools (p = 0.002), lower experience of toothbrushing instruction (p < 0.001) and lower self-check-up of their intra-oral condition using a mirror (p = 0.005). A higher prevalence of dental check-up within a year was associated with a higher level of periodontitis (p = 0.029).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, categorized by smoking status

Table 2 shows the adjusted mean number of teeth present, when categorized by smoking status, the percentage of subjects who had more than eight missing teeth and the ORs of having more than eight missing teeth, among current smokers and former smokers compared with those who had never smoked. There was no significant relationship between the adjusted mean number of teeth and smoking

Table 1. Characteristics of the subjects by number of teeth and periodontal status

		Number of teeth				Periodontal status					
	п	≥ 20		≤ 19			Perio- dontitis ^a		Not perio- dontitis		
		n	%	n	%	p value	n	%	n	%	p value
Age in 20	05 (yea	ars)									
40-49	216	205	25.5	11	3.9	< 0.001	44	15.6	172	21.3	0.094
50-59	303	256	31.8	47	16.6		74	26.2	229	28.4	
60-69	349	244	30.3	105	37.1		102	36.2	247	30.6	
70–75	220	100	12.4	120	42.4		62	22.0	158	19.6	
Frequenc	y of da	ily too	othbrus	hing							
≥ 2	697	542	67.3	155	54.8	< 0.001	185	65.6	512	63.5	0.291
< 2	391	263	32.7	128	45.2		97	34.4	294	36.5	
Using der	ntal flo	ss or i	nterden	tal bru	sh						
Yes	378	300	37.3	78	27.6	0.002	92	32.6	286	35.5	0.214
No	710	505	62.7	205	72.4		190	67.4	520	64.5	
Experienc	e of to	othbru	ushing i	nstruc	tion						
Yes	722	565	70.2	157	55.5	< 0.001	188	66.7	534	66.3	0.480
No	366	240	29.8	126	44.5		94	33.3	272	33.7	
Self-check	c of tee	eth and	l gums	using a	a mirro	r					
Yes	508	395	49.1	113	39.9	0.005	139	49.3	369	45.8	0.172
No	580	410	50.9	170	60.1		143	50.7	437	54.2	
Dental ch	leck-up	within	n a yea	r							
Yes	436	313	38.9	123	43.5	0.100	127	45.0	309	38.3	0.029
No	652	492	61.1	160	56.5		155	55.0	497	61.7	

^aAt least one site with pocket depth of 6 mm or more.

Table 2. Mean number of teeth present, percentage and odds ratios (ORs) of more than eight teeth lost, by smoking status

	Adjusted mean number of teeth present ^a		Percent jects withan ei	tage of sub- ith more ght teeth lost	Adjusted ORs of more than eight teeth lost ^a	
Smoking status	Mean	SE	%	$(n/N)^{\rm b}$	ORs ^c	95% CIs
Current smokers	21.4 ettes per dav	0.5	26.2	(83/317)	1.67	1.12-2.50
> 21	21.1	0.7	28.6	(13/63)	2.27	1 14-4 52
16-20	21.2	0.5	24.1	(33/137)	1.65	0.97-2.81
≤ 15 <i>p</i> -for-trend	21.8 0.120	0.5	27.0	(31/115)	1.30 0.053	0.75–2.24
Former smokers	21.4	0.4	26.8	(113/421)	1.35	0.94–1.94
Number of cigare	ettes per day					
≥ 21	21.3	0.6	28.3	(32/113)	1.49	0.89-2.55
16-20	20.3	0.5	31.2	(49/157)	1.72	1.06-2.79
≤ 15 <i>p</i> -for-trend	21.9 0.068	0.6	20.5	(25/122)	0.85 0.060	0.48-1.48
Never smoked	22.0	0.5	24.9	(87/350)	1.00	Reference

^aAdjusted for age and oral health behavior. Two cases in current smokers and 29 cases in former smokers were deleted as a result of missing values.

 ${}^{b}n/N$ where n = subjects with > 8 lost teeth and N = total sample.

^cNever smoked as a reference.

CI, confidence interval; SE, standard error.

status; however, current smokers and former smokers had fewer teeth (0.6 and 0.6, respectively) than those who had never smoked. In comparison to those whom had never smoked, the OR was 1.67 (p = 0.011) for having more than eight missing teeth among current smokers. However, there was no difference between former smokers and those who had never smoked.

The adjusted ORs of having more than eight missing teeth were significantly higher in current smokers who smoked 21 or more cigarettes per day and in former smokers who smoked 16–20 cigarettes per day compared with those who had never smoked. However, an increasing tendency was not observed among current smokers. Namely, there was not a tendency for an increased OR of having more than eight missing teeth among former smokers compared with those who had never smoked.

Percentage and ORs of periodontitis categorized by smoking status

Table 3 shows the percentage and adjusted ORs of subjects with periodontitis among current smokers and former smokers compared with those who had never smoked. In comparison with those who had never smoked, the OR of subjects with periodontitis among current smokers was 1.74 (p = 0.003); however, there was no significant difference between former smokers and those who had never smoked.

The adjusted ORs of subjects with periodontitis were significantly higher in current smokers who smoked 16 or more cigarettes per day than in those who had never smoked, and an increasing tendency was observed among current smokers. However, the increased ORs of subjects with periodontitis among former smokers, compared with those who had never smoked, was not as strong, although the trend approached significance (p = 0.052).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, categorized by smokingcessation years

Table 4 shows the adjusted mean number of teeth present, the percentage of subjects who had more than eight missing teeth and the ORs of having more than eight missing teeth, when categorized by smoking-cessation years. The reference was those who had never smoked. There was an increasing trend in the adjusted mean number of teeth present with an increase in the number of smoking-cessation years (p for trend = 0.005). Former smokers, with fewer than 11 smoking-cessation years, had 3.9 fewer

Table 3. Percentage and odds ratios (ORs) of subjects with periodontitis by smoking status

	Percentag with perio	e of subjects odontitis ^a	Adjusted ORs of subjects with periodontitis ^b		
Smoking status	%	$(n/N)^{c}$	ORs ^d	95% CIs	
Current smokers	31.1	(97/312)	1.74	1.21-2.50	
Number of cigarette	es per day				
≥ 21	38.1	(24/63)	2.53	1.39-4.60	
16-20	30.6	(41/134)	1.83	1.14-2.93	
≤ 15	28.3	(32/113)	1.44	0.88-2.37	
p-for-trend			0.001		
Former smokers	26.2	(107/408)	1.27	0.90-1.78	
Number of cigarette	es per day				
≥ 21	28.2	(31/110)	1.43	0.87-2.34	
16-20	29.7	(44/148)	1.53	0.99-2.38	
≤ 15	22.3	(27/121)	0.95	0.57-1.58	
p-for-trend			0.052		
Never smoked	23.1	(78/338)	1.00	Reference	

^aAt least one site with pocket depth 6 mm or more. Two cases in current smokers and 29 cases in former smokers were deleted as a result of missing values.

^bAdjusted for age and oral health behavior.

 ${}^{c}n/N$ where n = subjects with periodontitis and N = total sample.

^dNever smoked as a reference.

CI, confidence interval.

Table 4. Mean number of teeth present, percentage and odds ratios (ORs) of more than eight teeth lost, by smoking cessation years in former smokers

	Adjusted mean number of teeth present ^a		Percentage of subjects with more than eight teeth lost		Adjusted ORs of more than eight teeth lost ^a	
Smoking cessation years	Mean	SE	%	$(n/N)^{\mathrm{b}}$	ORs ^c	95% CIs
≤ 10	19.9	0.5	27.6	(48/174)	2.02	1.23-3.30
11-20	21.0	0.6	25.7	(26/101)	1.17	0.65-2.08
21-30	21.7	0.7	25.6	(22/86)	1.69	0.90-3.17
≥ 31	23.8	0.8	26.3	(15/57)	0.59	0.29-1.17
<i>p</i> -for-trend	0.005				0.022	

^aAdjusted for age and oral health behavior.

 ${}^{b}n/N$ where n = subjects with > 8 lost teeth and N = total sample.

^cNever smoked as a reference.

teeth than those with 31 or more years of smoking cessation.

Using never-smokers as a reference, an OR of 2.02 was found for having more than eight missing teeth in those who had stopped smoking 11 years ago or less. The OR of having more than eight missing teeth tended to decrease with an increase in the number of smoking-cessation years (p for trend = 0.022). In those who had stopped smoking for 11 or more years, no significant increase in ORs was seen.

Percentage and ORs of periodontitis, categorized by the number of smoking-cessation years

Table 5 shows the percentage and the adjusted ORs of subjects with periodontitis when categorized by smokingcessation years. The reference group was those who had never smoked. The percentage of subjects with periodontitis was over 30% in former smokers with fewer than 11 smoking-cessation years and about 20% in former smokers with 11 or more smoking-cessation years.

Using never-smokers as a reference, an OR of 1.88 was obtained for subjects with periodontitis who had stopped smoking less than 11 years ago. The ORs of subjects with periodontitis tended to decrease as the number of smoking-cessation years increased (p for trend = 0.012). In those who had stopped smoking for 11 or more years, no significant increase in the ORs was seen.

Discussion

This study had some limitations. The participation rate in the dental survey

Table 5. Percentage and odds ratios (ORs) of subjects with periodontitis by smoking cessation years in former smokers

	Adjusted jects with periodon	ORs of sub- 1 titis ^a	Percentage of subjects with periodontitis ^b		
Smoking cessation years	%	$(n/N)^{c}$	ORs ^d	95% CIs	
≤ 10	32.9	(55/167)	1.88	1.23-2.88	
11-20	21.9	(21/96)	0.99	0.57-1.72	
21-30	22.1	(19/86)	0.99	0.56-1.77	
≥ 31	19.6	(11/56)	0.71	0.35-1.48	
<i>p</i> -for-trend			0.012		

^aAt least one site with a pocket depth of 6 mm or more.

^bAdjusted for age and oral health behavior.

 ${}^{c}n/N$ where n = subjects with periodontitis and N = total sample.

^dNever smoked as a reference.

was low overall (about 10%) and especially among the male residents. However, the frequencies of smoking status and the percentages of those with more than eight missing teeth and periodontal diseases were similar to those of the national survey conducted in 2005 in Japan (30,31). Therefore, both the smoking status and the dental status of this sample were considered to be close to that of Japanese men in the national survey. Because of the low prevalence of female smokers, this study examined only men. However, the prevalence of smoking among women in their 20s and 30s has recently increased in Japan (30). The association between number of teeth and smoking status was significant in a study using Japanese National Survey data in 2006 (16). The adjusted OR of having more than eight missing teeth in current female smokers compared with those who had never smoked was 2.14. and meaningful differences between current smokers and never-smokers were evident in the > 40 years agegroup in women (16). Hence, we suggest that further research is needed into smoking cessation in both men and women and on its relationship with other lifestyle health-behavior activities

A further limitation may also be the definition of periodontal diseases used in this study. Subjects having one or more teeth with a pocket depth of 6 mm or more were defined as having periodontitis. In other studies, periodontal diseases have been defined by clinical attachment loss or alveolar bone level, and bleeding points, which together may reflect the periodontal status more accurately (32-35). However, pocket depth alone is a useful indicator that reflects the periodontal status (36,37). In Japan, most dentists do not measure attachment loss but they do measure pocket depth routinely in their dental work. In this study, many dentists who participated and were therefore trained in the study protocol were familiar with pocket depth as an indicator of periodontal disease. Therefore, pocket depth was included in the training manual as the study indicator of periodontitis. In addition, in the national survey in Japan, periodontal disease was measured using the CPI. A CPI code of 3 (mild periodontitis) means that subjects had one or more teeth with a pocket depth of 4-6 mm, and a CPI code of 4 (severe periodontitis) means that subjects had one or more teeth with a pocket depth of 6 mm or more (31). The present study thus provided a good comparative indicator with the code 4 CPI indicator in defining severe periodontitis. In this study, pocket depth was measured using pocket probes that were used in each dental clinic; however, no information was collected on the type of probe used in each practice and no reproducibility tests of clinical assessment were conducted. Therefore, some misclassification might exist in the results. However, clinical assessment in this study was carried out in a manner similar to that of the regular therapeutic intervention of participating dentists.

With respect to smoking status, the Comprehensive Smoking Index has been used as an effective index for analysis (38); however, as we did not collect information about smoking years, we could not use this index.

In addition, we could not include the socioeconomic status (SES) of subject in the model. The SES is often cited as a potential confounder. Self-rated health may be associated with social inequality in Japan (39). Furthermore, a negative association reported between smoking and SES, such as estimated by educational background (40), has been reported in Japan. That is, smoking is more prevalent in those of a higher educational status. Furthermore, in a previous report, some variables used for adjustment, for example, frequency of daily toothbrushing, could compensate for the direct effect of SES (16).

This study examined the association between smoking status and number of teeth and periodontal status. The odds of having more than eight missing teeth among current smokers, and the odds of periodontitis, were higher in current smokers than in those who had never smoked. A significant, negative association between number of teeth and smoking status was reported. This is consistent with other reports and also in the Japanese National Survey data, where the adjusted OR of current smokers, in comparison with those who had never smoked, among men, was 2.22 (16). The national report also found a significant, negative association between severe periodontitis and smoking status where the adjusted OR of current smokers was 1.40 (10).

Previous Japanese reports have not found any significant differences in the number of teeth retained, the odds of having more than eight missing teeth and the presence of periodontitis between former smokers and those who had never smoked (16-18). Our results were also consistent with these reports. However, the risk for some former smokers of having tooth loss and periodontal diseases were different from those who had never smoked. Consideration should also be given to those who have ceased smoking. In this study, subjects who had ceased smoking for 11 or more years had the same odds of having more than eight missing teeth, and the same level of periodontitis, as those who had never smoked. By contrast, those who had ceased smoking for a shorter period of time (10 years or less) had an OR of 2.02 of having more than eight missing teeth and an OR of 1.88 for the presence of periodontitis. Therefore, ceasing smoking may be a potentially influential factor for improving oral health.

There are few studies on dental diseases regarding the relationship with the length of time of smoking cessation required to gain health benefits (41). In USA, the risk of tooth loss among subjects who had ceased smoking for 13 years was not very different from those who had never smoked. In Japan, it was reported that more than 21 years of smoking cessation is necessary for smokers to have the same number of teeth as nonsmokers, and the ORs of having more than eight missing teeth tended to decrease with an increasing number of smoking-cessation years (19). Our results are similar to these previous reports. The results of this study suggest that the risk of tooth loss and periodontitis decreases with smoking cessation, but that it may take at least 10 years of abstinence for the risk to return to the level of those who have never smoked.

These findings should be of importance to the Japanese healthcare strategy, as a lifestyle intervention that could encourage current smokers to quit and to remain abstinent. It would be most opportune for dental personnel to encourage patients to not only stop smoking but also to practice good oral health behavior to maintain their oral health status.

Based on the relationships shown in this study, it is suggested that the dental profession should take a more prominent role in advising patients to stop smoking.

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