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ORIGINAL ARTICLE

Relationship of smoking and smoking cessation with number of teeth present: JPHC Oral Health Study*

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BACKGROUND: Smoking is associated with the number of teeth. The purpose of this study was to determine the relationship of number of teeth with smoking and smoking cessation.

METHODS: Subjects included 547 males aged between 55 and 75 years. Oral examinations were conducted in 2005. Smoking status information was collected from questionnaire surveys conducted in 1990, 1995, 2000, and 2005. The relationship between having more than eight missing teeth and smoking status was estimated with adjusted odds ratio.

RESULTS: Comparing with never smokers, odds ratios of having more than eight missing teeth among current and former smokers were 1.96 and 1.86, respectively. The odds ratios in those who had stopped smoking for ≤10 years was 3.02, and for those who had ceased smoking for 11–20 years was 2.66. In those who stopped smoking for 21 years or more, there was no increase in the odds ratio.

CONCLUSION: Smoking had a positive association with the number of missing teeth and smoking cessation is beneficial for maintaining teeth. The odds of having more than eight missing teeth in those who had never smoked was equal to that of individuals who reported that they had stopped smoking for 21 years or more.

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Keywords: missing teeth; smoking; smoking cessation

Introduction

Tooth loss affects activities such as speaking, smiling, chewing and tasting. In 1989, the Japanese Ministry of Health and Welfare proposed the 8020 Campaign, and since then this national oral health campaign has been conducted with the co-operation of the Japanese Dental Association throughout Japan. The concept behind the 8020 program is to maintain a high quality of life by preventing tooth loss throughout life. The '80' signifies the average life expectancy of Japanese people, and the '20' indicates the critical number of natural teeth needed to maintain a good eating and chewing function throughout life (Hashimoto et al, 2006a,b). According to the national dental survey in 2005, however, the current mean number of teeth present in those 80 years of age is 8.8 (The Statistical Analysis Committee on the Survey of Dental Diseases, 2006).

Smoking has been associated with a higher prevalence of edentulousness and fewer remaining teeth (Ahlqwist et al, 1989; Linden and Mullally, 1994; Krall et al, 1997, 2006b; Axelsson et al, 1998; Ylostalo et al, 2004; Dietrich et al, 2007). The main biological causes of tooth loss are periodontal disease and dental caries (Morita et al, 1994). A complex relationship among bacteria, the host, and behavioral and environmental factors determines the onset and progress of these oral diseases. Smoking is one important risk factor for periodontal disease (Osterberg and Mellstrom, 1986; Grossi et al, 1994, 1995; Albandar et al, 2000; Tomar and Asma, 2000; Bergström, 2003). A causal association has been established between smoking and periodontal disease (U.S. Department of Health and Human Services, 2004). As periodontal disease progresses, the gingival margins regress and root surfaces are exposed to acid-producing bacteria. Therefore, periodontal disease also increases the risk of caries on the root surfaces of teeth (U.S. Department of Health and Human Services, 2004).

Because various factors influence tooth loss, confounding factors should therefore also be considered while investigating the relationship of smoking and smoking cessation with tooth loss. Body mass index (BMI), vitamin C intake, alcohol consumption and educational background can all be associated with tooth loss (Gilbert et al, 2003; Klein et al, 2004).

In Japan, an association between smoking and tooth loss has been identified by a number of researchers (Yoshida *et al*, 2001; Yoshihara *et al*, 2005; Hanioka *et al*, 2007), but most such investigations have been cross-sectional, with only a few retrospective studies (Okamoto *et al*, 2006). In particular, few epidemiological studies have investigated the relationship of smoking cessation with the risk of tooth loss.

The purpose of this study was to investigate the relationship of smoking and smoking cessation with the number of teeth. The association between the number of smoking cessation years and having more than eight missing teeth (i.e. fewer than 20 teeth present) was analyzed using the data of an ongoing prospective study, the Japanese Public Health Center-based Prospective Study (JPHC Study).

Methods

The subjects in the present study included a subsample of participants in the district of the Yokote Public Health Center belonging to the JPHC Study Cohort I (Tsugane and Sobue, 2001). In this district, 15,782 subjects (7,559 men, 8,223 women) who were 40–59 years of age as on December 31, 1989, were respondents to the JPHC study and 11,754 subjects (5,471 men, 6,283 women) answered the questionnaire. The subjects were recruited by mail to participate in a dental health checkup at district dental clinics in May 2005. A total of 1,518 subjects (706 men, 812 women) underwent clinical dental examination between July 1, 2005 and January 31, 2006.

The number of teeth present was objectively determined by dental examination by the district's dentists at the dental clinics of Yokote city and Hiraka County Dental Association members in 2005. Only 28 permanent teeth were examined and third molars were excluded.

The smoking status of the subjects was derived from a self-completed questionnaire administered in 1990, 1995, 2000, and 2005, in which the questionnaire items asked about smoking status at the time of the survey. The response options were: 'Currently smoking'; 'Quit smoking'; and 'Not smoking'. Based on these four questionnaires, smoking status was categorized into three groups: 'Never smokers', 'Current smokers' and 'Former smokers'. 'Never smokers' were persons who answered 'Not smoking' in both 1990 and 2005 and answered 'Not smoking' in 1995 and 2000 or had a missing value in 1995 and 2000. 'Current smokers' were individuals who answered 'Currently smoking' in 2005, regardless of answers in 1990, 1995 and 2000. 'Former smokers' were persons who answered 'Quit smoking' in 2005 or those who answered 'Not smoking' in 2005 but 'Currently smoking' or 'Quit smoking' in 1990. We excluded the subjects whose information of smoking status at the 1990 questionnaire was not available and whose information of smoking status during 15 years showed a discrepancy such as 'Quit smoking' in 2005 and 'Not smoking' in 1990.

The question about the age when subjects started smoking was asked in 1990, and the questions about the number of cigarettes smoked per day and the age when they quit smoking were asked in 2005. In case the data in 2005 were not available, we used the data at latest available questionnaires between 1990 and 2000. The number of cigarettes smoked per day and the total number of smoking years were calculated for current smokers and former smokers. To calculate the smoking years for current smokers, a calculation was made using the age of start of smoking from the 1990 questionnaire and age in 2005. For smoking years for former smokers, the age of quitting smoking from the 2005 questionnaire and the age of starting smoking from the 1990 questionnaire or the age of quitting smoking from latest available questionnaire between 1990 and 2000 and the age of starting smoking from the 1990 questionnaire were used for the calculation. Finally, the smoking-cessation years for former smokers were calculated with the age of quitting smoking from the 2005 questionnaire and the age in 2005 or the age of quitting smoking from latest available questionnaires between 1990 and 2000 and the age in 2005.

For current smokers, the level of smoking exposure was categorized in terms of smoking years (≤ 40, 41–45, ≥ 46 years) and the number of cigarettes smoked per day (≤ 15, 16–20, ≥ 21 cigarettes). For former smokers, smoking exposure was categorized in terms of smoking years (≤ 20, 21–30, ≥ 31 years), the number of cigarettes smoked per day (≤ 15, 16–20, ≥ 21 cigarettes), and smoking cessation years (≤ 10, 11–20, 21–30, ≥ 31 years).

Body mass index, vitamin C intake, alcohol consumption and educational background of the subjects were obtained from the self-completed questionnaires conducted as the baseline survey of the JPHC Study in 1990. Vitamin C intake was calculated from food frequency questionnaires, which asked about the average consumption of 44 food items, during the previous month and adjusted by energy intake. These variables were categorized as following; BMI (24.9 kg/m^2 or less, or 25.0 kg/m^2 or more), vitamin C intake (100 mg/day or more, or less than 100 mg/day), alcohol consumption (never, sometimes, everyday), educational background (junior high school, high school, university or college).

The percentages of current smokers and former smokers among female subjects in 1990 were only 2.1% and 1.0%, respectively. This number was too low for statistical analysis, thus female subjects were excluded from analyses. After further exclusion of subjects with missing covariate information used for the adjustment in the statistical analysis, 547 men were considered in the final analysis. This survey was approved by the Ethics Committee of Tokyo Medical and Dental University and the Ethics Committee of the National Cancer Center, Tokyo, Japan.

Statistical analysis
The chi-squared test and one-way analysis of variance were used to detect the differences of the distribution by the number of teeth present. Analysis of covariance was used to calculate adjusted mean number of teeth present

by controlling for age, BMI, vitamin C intake, alcohol consumption and educational background according to smoking status, smoking years, the number of cigarettes smoked per day and smoking-cessation years.

Then, we used a logistic regression to obtain adjusted odds ratios (ORs) and 95% confidence intervals (CIs) to examine the association between having more than eight missing teeth and smoking status. In this analysis, dependent variables were dichotomized in terms of 8020 achievement; the subjects were classified into two categories in terms of 8020 achievement: (i) more than eight missing teeth, i.e. retaining fewer than 20 teeth and (ii) eight or less missing teeth, i.e. retaining 20 or more teeth. Statistical adjustments were made for age, BMI, alcohol consumption, vitamin C intake, and educational background because previous studies reported positive association between these factors and tooth loss (Gilbert et al, 2003; Klein et al, 2004). We estimated ORs of having more than eight missing teeth according to number of cigarettes smoked per day and smoking years among current and former smokers compared with that among never smokers by including both variables simultaneously into the model to weigh their relative importance. Two-sided P-values less than 0.05 were considered to be statistically significant. SPSS14.0J (SPSS Japan, Tokyo, Japan) was used to analyze the data.

Results

Participation rate
In this study, the participation rate was 12.9% among the males who answered the baseline questionnaire survey of the JPHC Study (1990) among the Yokote districts residents.

Distribution of smoking status
At the 2005 questionnaire survey, 135 subjects (24.7%) answered 'Currently smoking', 212 (38.8%) answered 'Quit smoking', and 200 (36.6%) answered 'Not smoking'. The subject's smoking history was confirmed by reference to the 1990, 1995, and 2000 questionnaires. Figure 1 shows the changing pattern of smoking status from the data obtained from the 1990 questionnaire to the data within the final questionnaire. The number of subjects who answered

'Currently smoking' in 1990 was 227, and of these subjects, 97 (42.7%) later stopped smoking while 130 (57.3%) continued smoking until 2005. The number of those who answered 'Quit smoking' in 1990 was 154, and of these subjects, 4 (2.6%) had started smoking again by 2005 while 150 (97.4%) continued not to smoke. The number of subjects who answered 'Not smoking' in 1990 was 166, and of these subjects, 161 (97.0%) continued not to smoke, 1 (0.6%) began smoking, and 4 (2.4%) started but then stopped smoking again by 2005. In the 2005 questionnaire, 200 subjects answered that they were 'Not smoking'. However, 39 (19.5%) of these were, in fact, former smokers. They had answered 'Not smoking' instead of 'Quit smoking', even though they had smoked in the past. The final grouping of smoking status therefore was: 135 current smokers (24.7%), 251 former smokers (45.9%), and 161 who had never smoked (29.4%).

Characteristics by number of teeth present
Age of the subjects ranged from 55 to 75 years in 2005 (mean = 65.6, s.d. = 5.8). The mean age by the number of teeth present was 67.7 ± 5.8 for subjects with 0–19 teeth (i.e. more than eight missing teeth) and 64.4 ± 5.5 for subjects with 20–28 teeth (i.e. eight or less missing teeth). The difference between the two groups was statistically significant (P < 0.001). Table 1 shows the distributions of age group, BMI, vitamin C intake, alcohol consumption, and educational background by the number of teeth present. Subjects with more than eight missing teeth were older (P < 0.001), had a lower BMI (P = 0.021), and a lower educational background (P < 0.001).

Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking status
Table 2 shows the adjusted mean number of teeth present by smoking status, the percentage of subjects having more than eight missing teeth and ORs of having more than eight missing teeth among current smokers and former smokers compared with that among never smokers. Current smokers (P = 0.050) and former smokers (P = 0.010) had fewer teeth than never smokers. In comparison with never smokers, ORs of having
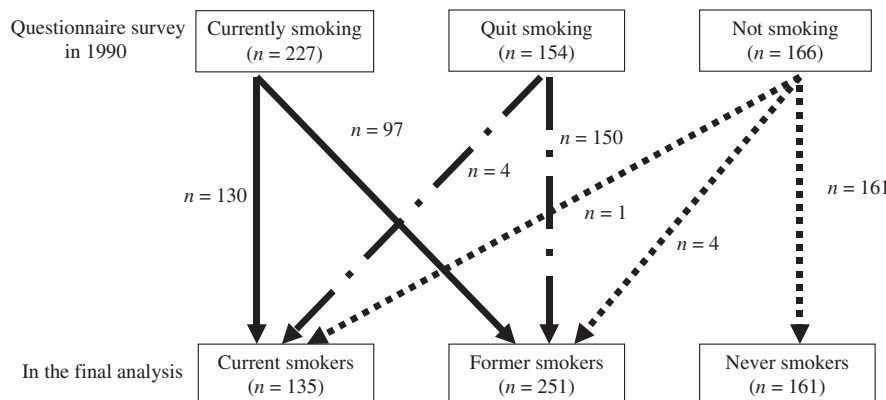

Figure 1 Changing pattern of smoking status

Table 1 Characteristics of the subjects by the number of teeth present

| | | Number of teeth present | | | | |
| | | 0–19 | | 20–28 | | |
	n	n	%	n	%	P value
Age in 2005 (years)						
55–59	101	21	10.7	80	22.9	< 0.001
60–64	140	34	17.3	106	30.3	
65–69	128	44	22.3	84	24.0	
70–75	178	98	49.7	80	22.9	
BMI (kg/m^2)						
−24.9	407	157	79.7	250	71.4	0.021
25.0 +	140	40	20.3	100	28.6	
Vitamin C intake (mg/day)						
100 +	306	103	52.3	203	58.0	0.115
< 100	241	94	47.7	147	42.0	
Alcohol consumption						
Never	59	24	12.2	35	10.0	0.201
Sometimes	187	58	29.4	129	36.9	
Everyday	301	115	58.4	186	53.1	
Educational background						
Junior high school	168	81	41.1	87	24.9	< 0.001
High school	282	94	47.7	188	53.7	
University or college	97	22	11.2	75	21.4	

Table 2 Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking status

| | Adjusted mean number of teeth present[a] | | Percentage of subjects with more than eight missing teeth | Adjusted ORs of having more than eight missing teeth[a] | |
Smoking status	Mean	SE		ORs[b]	95% CIs
Current smokers	19.0	0.7	39.3% (53/135)	1.96	1.16–3.31
Number of cigarettes smoked per day[c]					
≥ 21	18.6	1.2	38.1% (16/42)	2.07	1.06–4.44
16–20	20.2	1.1	35.8% (19/53)	1.43	0.71–2.85
≤ 15	19.0	1.3	43.6% (17/39)	2.08	1.00–4.37
P for trend	0.826			0.037	
Smoking years[c]					
≥ 46	18.5	1.6	50.0% (25/50)	1.98	0.97–4.04
41–45	19.1	1.3	41.0% (16/39)	2.26	1.04–4.92
≤ 40	20.5	1.6	24.4% (11/45)	1.66	0.70–3.94
P for trend	0.030			0.022	
Former smokers	18.8	0.5	39.0% (98/251)	1.86	1.18–2.95
Number of cigarettes smoked per day[c]					
≥ 21	18.4	0.9	38.0% (30/79)	2.03	1.08–3.80
16–20	18.1	0.9	45.2% (33/73)	2.00	1.07–3.71
≤ 15	20.4	0.8	33.0% (30/91)	1.32	0.71–2.41
P for trend	0.102			0.020	
Smoking years[c]					
≥ 31	16.6	0.9	55.6% (45/81)	3.03	1.64–5.62
21–30	18.9	0.9	36.0% (27/75)	1.91	1.01–3.62
≤ 20	21.4	0.9	24.1% (21/87)	0.99	0.52–1.90
P for trend	< 0.001			0.010	
Never smokers	21.1	0.6	28.6% (46/161)	1.00	(Reference)

[a]Adjusted for age, BMI, vitamin C intake, alcohol consumption and educational background. Number of cigarettes smoked per day and smoking years are mutually adjusted.
[b]Never smokers as a reference.
[c]One case in 'Current smokers' and eight cases in 'Former smokers' were deleted because of missing values.

more than eight missing teeth among current smokers and former smokers were 1.96 and 1.86 ($P = 0.010$ and 0.009, respectively).

In current smokers, there was no significant association between the adjusted mean number of teeth and number of cigarettes smoked per day. However, the greater the number of smoking years the smaller the adjusted mean number of teeth (P for trend = 0.030). Current smokers who had smoked for 46 years or more had 2.0 fewer teeth than those who had smoked 40 years or less. Former smokers who had smoked either 16–20 or 21 or more cigarettes per day had fewer teeth (2.3 and 2.0, respectively) than those who had smoked 15 or less cigarettes. Furthermore, the greater the smoking years, the less the adjusted mean number of teeth (P for trend < 0.001). Former smokers who had smoked for 31 years or more had, on average, 4.8 fewer teeth than those who smoked for 20 or less years.

The adjusted odds of having more than eight missing teeth were significantly higher in current smokers who smoked 21 or more cigarettes per day *vs* never smokers. In regard to smoking years, in comparison with never smokers, the adjusted odds among current smokers who had smoked for 41 years or more were higher. The adjusted odds of having more than eight missing teeth among former smokers who had smoked 16 or more cigarettes per day, or had smoked for 21 years or more, were higher in comparison with never smokers.

An increasing tendency was observed among former smokers. Namely, the ORs of having more than eight missing teeth among former smokers compared with that among never smokers increased with the number of cigarettes smoked per day (P for trend = 0.020) and the number of smoking years (P for trend = 0.010).

Mean number of teeth present, percentage of subjects and ORs of having more than eight missing teeth, by smoking cessation years
Table 3 shows the adjusted mean number of teeth present, the percentage of subjects who had more than eight missing teeth, and ORs of having more than eight missing teeth with never smokers as the reference, by smoking cessation years. Former smokers with fewer

Table 3 Mean number of teeth present, and percentage of subjects and ORs of having more than eight missing teeth, by smoking cessation years

| | Adjusted mean number of teeth present[a] | | Percentage of subjects with more than eight missing teeth | Adjusted ORs of having more than eight missing teeth[a] | |
Smoking cessation years	Mean	SE		ORs[b]	95% CIs
≤ 10	16.9	1.0	48.6% (35/72)	3.02	1.54–5.90
11–20	17.4	1.0	42.2% (27/64)	2.66	1.36–5.23
21–30	20.3	1.0	29.0% (20/69)	1.27	0.64–2.51
≥ 31	22.2	1.2	33.3% (15/45)	0.94	0.43–2.04
P for trend	< 0.001			< 0.001	

[a]Adjusted for age, BMI, vitamin C intake, alcohol consumption and educational background.
[b]Never smokers as a reference.

than 11 or 11–20 smoking cessation years had fewer teeth than those with 31 years or more of smoking cessation (the differences were 5.3 and 4.8, respectively). There was an increasing trend in the adjusted mean number of teeth with the increasing smoking cessation years (P for trend < 0.001). In addition, the adjusted mean number of teeth in those who ceased smoking for 21 years or more was 20 or more.

The percentage of subjects with more than eight missing teeth was over 40% in former smokers with fewer than 11 or 11–20 smoking cessation years, while it was about 30% in former smokers with 21 or more smoking cessation years. Using never smokers as a reference, the ORs of having more than eight missing teeth in those who had stopped smoking within less than 11 or 11–20 years were 3.02 and 2.66, respectively. ORs of having more than eight missing teeth tended to decrease with an increasing value in the number of smoking cessation years (P for trend < 0.001). In those who had stopped smoking for 21 years or more, no significant increase in ORs was seen.

Discussion

After confirming any status changes in the subjects' smoking behavior from 1990 to 2005, we examined the association between smoking status and number of teeth. The odds of having more than eight missing teeth among current smokers were higher in comparison with never smokers. In addition they had, on average, about two fewer teeth than never smokers. A significant negative association between number of teeth and smoking status was reported, using Japanese National Survey data, where the adjusted OR of current smokers in comparison with never smokers among male was 2.22 (Hanioka et al, 2007). The present results are consistent with that report. Many studies have also shown the number of cigarettes and smoking years to be related to tooth loss comparing current vs never smokers (Osterberg and Mellstrom, 1986; Ahlqwist et al, 1989; Krall et al, 1997; Axelsson et al, 1998; Albandar et al, 2000; Gilbert et al, 2003). We also found that the ORs of having more than eight missing teeth tended to increase when comparing current vs never smokers and for a declining number of teeth with increasing smoking years even after adjustment for the number of cigarettes smoked per day compared with never smokers.

Previous Japanese reports found no significant differences in the number of teeth retained or the odds of having more than eight missing teeth between former smokers and never smokers (Yoshida et al, 2001; Yoshihara et al, 2005; Hanioka et al, 2007). In contrast, this study did find differences, but these differences depended upon the number of years since smoking ceased. Subjects who ceased smoking for 21 years or more had, on average, 20 or more teeth present, and had odds of having more than eight missing teeth nearly equal to those who had never smoked. We should consider how the risk of tooth loss changes with smoking cessation in order to understand this finding. The reduction in the increased odds of having more than eight missing teeth in those who stopped smoking may be relatively rapid, but it takes many years before the odds of having more than eight missing teeth in former smokers equal that of never smokers.

Smoking cessation decreases the risk of certain diseases and in some cases reduces the risk to the same level as in those who had never smoked. The risk of lung cancer in males returns to the level of 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 (National Cancer Institute, 1997). The risk of coronary heart disease decreases within 2 years of smoking cessation (Baba et al, 2006), and approximately 15 years after smoking cessation, the mortality rates from coronary artery disease and stroke among former smokers approach those of never smokers (Burns, 2003). Total mortality and cancer mortality rates among male former smokers remain higher than those who never smoked even 20 years after quitting (LaCroix et al, 1991).

There are very few studies regarding dental diseases to assess the length of smoking cessation required for gaining health benefits. The risk of tooth loss among subjects who had quit smoking for 13 years was not very different from those who never smoked (Krall et al, 2006b), and our results are similar to this previous report. We could not measure risk in this study; nonetheless, we found that the adjusted ORs of having more than eight missing teeth did not significantly differ from unity when comparing subjects who had quit smoking for 21 years or more and those falling in the category of never smokers.

The mechanism behind the decreasing risk of tooth loss with smoking cessation could be attributed to a reduction in periodontal tissue damage. Smoking influences periodontal tissue because nicotine and other toxins contained in cigarettes suppress immunoactivity when absorbed into the bloodstream (Kornman and di Giovine, 1998). When oxygen in the periodontal pocket decreases (Hanioka et al, 2000), anaerobes that cause periodontal disease (e.g. Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis and Tannerella forsythensis) increase (Shiloah et al, 2000). Finally, the toxins directly destroy periodontal tissue (Sayers et al, 1999). These phenomena produce numerous deep periodontal pockets, an increased absorption of the alveolar bone supporting the teeth and increased tooth mobility, leading to tooth loss. There is, furthermore, emerging evidence suggesting that the progression of periodontal disease may or may not be amplified by unavoidable microbial colonization. In addition, it has been speculated that interference with vascular and inflammatory phenomena may be one potential mechanism for the induction of periodontal disease because of smoking (Bergström, 2004).

Associations have been reported between smoking and root caries (Hahn et al, 1999), coronal caries (Axelsson et al, 1998) and endodontic treatment (Krall et al, 2006a,b). A causal association with smoking has been suggested for root caries; however, the mechanism of action and the reason for this association with coronal dental caries by smoking is not clear.

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One advantage of the current study design was that the subjects' history of smoking status could be confirmed from four self-completed questionnaires during the 15-year period from 1990 to 2005. In the 2005 questionnaire, about 20% of subjects who answered 'Not smoking' had answered 'Currently smoking' or 'Quit smoking' at least one time in the 1990 to 2000 questionnaires. If they had been categorized as 'Never smokers', then the odds of having more than eight missing teeth among never smokers would have been overestimated. In the present study, however, a never smoker was strictly defined as a person who answered 'Not smoking' at both the 1990 and 2005 questionnaires and never answered 'Currently smoking' or 'Quit smoking' in the 1995 or 2000 questionnaires. The measurement of smoking status from a single questionnaire would be more vulnerable to misclassification and recall bias. Although if a slight misclassification remained, this type of misclassification would result in an attenuation of estimation of ORs. Nonetheless, we observed a significant positive association between having more than eight missing teeth and current smoking and past smoking.

This study had some limitations. Participation rate in the dental survey was low among the males who answered the baseline questionnaire survey of JPHC study (1990) of the Yokote districts residents. However, the frequencies of smoking status and the percentage of those having more than eight missing teeth were similar to those of the national survey conducted in the same year (Ministry of Health Law, 1991; The Statistical Analysis Committee on the Survey of Dental Diseases, 2006) in Japan. In that survey among males over 60 years of age, 28.9% answered 'Currently smoking', 35.0% answered 'Quit smoking', and 36.1% answered 'Not smoking' (compared with 24.7%, 38.8%, and 36.6% in this study, respectively). The percentage of subjects having more than eight missing teeth in 55- to 74-year-old males was 62.6% in the national survey (compared with 64.0% in this study). Therefore, both smoking and dental status of this sample were considered close to those of all Japanese males in the national survey. The information of past oral health practices and past regular dental visits was not available for this study, although these behavioral factors may influence tooth loss (Kressin et al, 2003; Cunha-Cruz et al, 2004). Previous studies have reported an increased risk of tooth loss with smoking and a decreased risk with smoking cessation after adjusting for oral health behavior (Krall et al, 2006b). We therefore consider the results of this study to be not far from the actual situation in Japan. The participants' dentate status was unknown at baseline; therefore, it was not possible to model incident tooth loss.

This study examined only males, because of the low prevalence of female smokers in the 1990 baseline survey. However, smoking prevalence among females in their twenties and thirties has recently increased in Japan. Among 38- to 60-year-old Swedish females, the mean number of lost teeth during a 12-year follow up was 3.5 among current smokers and 2.1 among those who had never smoked (Ahlqwist et al, 1989). In Japan, the association between the number of teeth and smoking status was significant in a study using Japanese National Survey data. The adjusted OR of having more than eight missing teeth in current female smokers compared with those who had never smoked was 2.14 (Hanioka et al, 2007). Hence, we recommend smoking cessation for both males and females.

In Japan, recommendations to stop smoking are made to patients mainly in medical settings. However, smoking cessation promotion by dentists and dental hygienists has an advantage over promotion by other health professionals. Because current smokers can directly see and recognize the symptoms of tobacco-related oral diseases, it should be helpful to motivate them to stop smoking and, thereby, help prevent the development of other severe health hazards at an early stage. Dental professionals should actively co-operate with medical professionals to conduct effective smoking cessation programs.

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Author contributions

Tomohito Yanagisawa, Tomomi Marugame, Satoko Ohara, Manami Inoue, Shoichiro Tsugane and Yoko Kawaguchi contributed to the research design. Tomohito Yanagisawa and Tomomi Marugame contributed to analysis of data. Tomohito Yanagisawa contributed in drafting the paper. Tomomi Marugame, Satoko Ohara, Manami Inoue, Shoichiro Tsugane and Yoko Kawaguchi worked on the critical revision of the paper.

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Appendix

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