Relationship Between Intake of Green Tea and Periodontal Disease

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Background: Green tea is a very popular beverage, and in vitro studies have shown that green tea polyphenols inhibit the growth and cellular adherence of periodontal pathogens and their production of virulence factors. We investigated the epidemiologic relationship between the intake of green tea and periodontal disease.

Methods: We analyzed 940 Japanese men aged 49 to 59 years as part of a comprehensive health examination. Probing depth (PD), clinical attachment loss (AL), and bleeding on probing (BOP) were used as the periodontal parameters. We examined the relationship between the intake of green tea and periodontal parameters. The intake of green tea was defined as the number of cups per day in a self-administered questionnaire.

Results: The intake of green tea was inversely correlated with the mean PD, mean clinical AL, and BOP. In multivariate linear regression models, every one cup/day increment in green tea intake was associated with a 0.023-mm decrease in the mean PD (P <0.05), a 0.028-mm decrease in the mean clinical AL (P <0.05), and a 0.63% decrease in BOP (P <0.05), after adjusting for other confounding variables.

Conclusion: There was a modest inverse association between the intake of green tea and periodontal disease. *J Periodontol 2009;80:372-377.*

KEY WORDS

Epidemiology; green tea; periodontal disease; periodontitis.

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Periodontal disease is a chronic disease that is prevalent in adults. The incidence and progression of periodontal disease is related causally to periodontal pathogens,[1,2] as well as to various host and environmental factors.[3,4] Eating habits and nutritional intake affect periodontal disease. Many studies have reported that consumption of vitamin C and calcium is linked to periodontal disease[5,6] and that the consumption of whole-grain and lactic acid foods has a prophylactic effect on periodontal disease.[7-9]

Green tea is a popular drink, and the intake of green tea and its components, such as catechin, had a preventive effect against cancer development and cardiovascular disease in experimental and epidemiologic studies.[10,11] Several in vitro studies have suggested that green tea catechins, such as (–)-epigallocatechin gallate (EGCg), inhibit periodontal pathogens[12-14] and the destruction of periodontal tissue.[15,16] A pilot clinical study[12] showed that periodontal treatment with the slow-release local delivery of catechin improved periodontal status. However, it is not clear whether the daily intake of green tea has a beneficial effect on periodontal health. Therefore, we examined the epidemiologic relationship between the daily intake of green tea and periodontal disease through a comprehensive health examination in middle-aged Japanese men.

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MATERIALS AND METHODS

Study Population

More than 95% of the men enlisted in the Self-Defense Force in Fukuoka, Japan, attended a comprehensive health examination that included a 5-day admission to the Self-Defense Force Fukuoka Hospital in the 5 years before retirement. The examination was conducted for preretirement healthcare for the subjects. We examined a total of 1,123 men aged 49 to 59 years between January 2000 and March 2002. Of these, 940 subjects who had ≥20 teeth and all of the data required for analysis were studied to ensure an adequate assessment of periodontal condition. The subjects provided oral consent to participate in this study. The study was conducted in accordance with the Helsinki Declaration, and the design and procedures were approved by the Self-Defense Force, Fukuoka Hospital, and the Ground Staff Office.

Measurements

Oral examination was carried out by one dentist trained to perform a clinical examination of oral health status using a normal dental chair. Probing depth (PD) and clinical attachment loss (AL) were measured using a periodontal probe† at the mesio-buccal and mid-buccal sites for all remaining teeth, except third molars, following the method of the Third National Health and Nutrition Examination Survey.[17] Gingival bleeding on probing (BOP) was evaluated by calculating the percentage of teeth exhibiting gingival bleeding within a few seconds of probing the periodontal pockets. The examiner reliability of the periodontal examination was verified by an intraexaminer calibration of volunteers; the percentage agreement (within ±1 mm) ranged from 91.0% to 100% for PD and from 89.0% to 100% for clinical AL. The kappa value ranged from 0.86 to 1.00 for PD and from 0.84 to 1.00 for clinical AL. The examiner was masked to the answers of the questionnaire while conducting the periodontal examination.

Each subject completed a self-administered questionnaire that assessed smoking history, alcohol intake, toothbrushing habits, and the daily intake of green tea; an examiner checked the answers orally. Smoking habit was quantified as the number of cigarettes smoked per day multiplied by the number of years smoked. The frequency of toothbrushing was divided into five categories and coded as follows: never = 1; sometimes = 2; once a day = 3; twice a day = 4; and three or more times a day = 5. We asked about the habitual frequency of drinking green tea as the number of cups per day and used it as a continuous variable in the analysis.

Physicians examined each subject's systemic condition. A blood sample was collected from the antecubital vein after an overnight fast to determine lipid and glucose levels. The body mass index was defined as the weight in kilograms divided by the square of the height in meters. Body fat was defined using foot-to-foot bioelectric impedance analysis using a body composition monitor.‡

Statistical Analysis

We used the mean PD, mean clinical AL, and BOP as dependent variables to reflect periodontal disease. We calculated the Spearman correlation coefficient among each periodontal parameter, the intake of green tea, and other study variables. We used simple linear regression analysis to examine the relationship between the intake of green tea and each periodontal parameter. Stepwise multivariate linear regression analysis was used to examine the effect of each independent variable on the periodontal parameters. The variables for which the correlation coefficient was significant were entered into the multivariate model. The statistical analyses were performed using a software program.§

RESULTS

The characteristics of the subjects were compared to the data for men 50 to 59 years old from the National Nutrition Survey of Japan, conducted in 2000 (Table 1).[18] Most of the data were similar; however, the subjects' systolic blood pressure and triglycerides were slightly lower and the high-density lipoprotein (HDL) cholesterol was slightly higher compared to the results of the National Nutrition Survey. The percentage of smokers (current and past) was 81.5% in this study and 76.7% in the National Nutrition Survey.

Table 1 shows the Spearman correlation coefficient of the study variables. The intake of green tea, smoking habit, number of teeth, and HDL cholesterol were significantly correlated with all of the periodontal parameters. The frequency of toothbrushing was associated with the mean PD and BOP, and the body fat and triglycerides were associated with BOP. The intake of green tea was correlated with the frequency of toothbrushing and number of teeth. There was no significant seasonal variation in mean green tea intake.

The simple linear regression analysis identified a significant relationship between the intake of green tea and each periodontal parameter (Table 2). Table 3 shows the results of the stepwise multivariate linear regression to evaluate each independent variable in relation to the periodontal parameters. The intake of green tea was significantly inversely correlated with all of the periodontal parameters. Every one cup/day increment in green tea intake was associated with a 0.023-mm decrease in mean PD ($P<0.05$), a 0.028-mm decrease in mean clinical AL ($P<0.05$), and a

† PCPUNC15, Hu-Friedy, Chicago, IL.
‡ TBF-401, Tanita, Tokyo, Japan.
§ SPSS version 15.0, SPSS Japan, Tokyo, Japan.

Table 1.

Characteristics of Variables and Spearman Correlation Coefficients

	Mean ± SD (range)	National Nutrition Survey[18]	Spearman Correlation Coefficient			
			Mean PD	Mean Clinical AL	BOP	Intake of Green Tea
Age (years)	52.4 ± 0.9 (49 to 59)	(50 to 59)	–0.04	–0.01	–0.03	0.03
PD (mm)	2.5 ± 0.8 (1.0 to 7.0)		–	0.77*	0.69*	–0.11*
Clinical AL (mm)	3.0 ± 1.0 (0.7 to 8.2)		0.77*	–	0.50*	–0.11*
BOP (%)	17.7 ± 19.0 (0 to 100)		0.69*	0.50*	–	–0.08†
Intake of green tea (cups/day)	3.5 ± 2.2 (0 to 12)		–0.11*	–0.11*	–0.08†	–
Smoking habit (pack-years)	23.3 ± 17.7 (0 to 87.5)		0.24*	0.30*	0.14*	–0.06
Alcohol intake (times/week)	4.4 ± 2.7 (0 to 7)		–0.01	–0.03	0.004	–0.04
Toothbrushing frequency (times/day)	3.8 ± 0.8 (1 to 5)		–0.13*	–0.02	–0.15*	0.09*
Teeth (n)	26.3 ± 2.9 (20 to 32)		–0.22*	–0.35*	–0.12*	0.07†
BMI (kg/m^2)	23.8 ± 2.6 (16.6 to 32.8)	23.6 ± 3.0	0.05	–0.03	0.03	–0.01
Body fat (%)	21.5 ± 4.4 (10.1 to 35.5)		0.06	–0.004	0.07†	–0.01
Systolic blood pressure (mm Hg)	128.9 ± 14.9 (90 to 220)	134.9 ± 19.5	0.03	0.003	0.05	0.03
Diastolic blood pressure (mm Hg)	82.6 ± 9.9 (46 to 126)	83.9 ± 11.7	0.02	–0.05	0.04	–0.02
Total cholesterol (mg/dl)	205.5 ± 33.1 (99 to 339)	204.0 ± 36.6	0.01	–0.05	0.05	–0.02
HDL cholesterol (mg/dl)	57.5 ± 15.9 (23 to 128)	54.1 ± 15.6	–0.09*	–0.11*	–0.09†	0.01
Triglycerides (mg/dl)	149.6 ± 124.2 (31 to 1,753)	164.3 ± 161.2	0.05	0.04	0.08†	0.01
Fasting plasma glucose level (mg/dl)	102.1 ± 19.2 (74 to 289)	101.7 ± 29.9	0.04	0.04	0.05	–0.02

– = not applicable.
* P <0.01.
† P <0.05.

0.63% decrease in BOP (P <0.05), after adjusting for other confounding variables.

DISCUSSION

We conducted a comprehensive health examination of males in their fifties and examined the relationship between the daily intake of green tea and periodontal disease. Most of the subjects in the Self-Defense Force were men, and men in their fifties have a relatively large number of existing teeth and a high prevalence of periodontal disease. The daily intake of green tea was significantly associated with indices of periodontal disease, including PD, clinical AL, and BOP, such that the more frequently the subjects drank green tea, the better was their periodontal condition.

Bacterial biofilm development in the marginal gingiva and periodontal pockets is important in the pathogenesis of periodontal disease. Previous in vitro studies showed that green tea catechin inhibits the growth of *Porphyromonas gingivalis*, *Prevotella intermedia*, and *Prevotella nigrescens*[12,14] and the adherence of *P. gingivalis* onto human buccal epithelial cells.[14] In addition, green tea catechins with the steric structures of 3-galloyl radial, EGCg, (–)-epicatechin gallate (ECg), and (–)-gallocatechin gallate, which are the major tea polyphenols, inhibit the production of toxic end metabolites of *P. gingivalis*.[19] These reports of the inhibitory effects of catechin contained in green tea on periodontal pathogens may provide the basis for the beneficial effect of the daily intake of green tea on periodontal health.

Periodontal disease is an infectious disease involving gingival inflammation and the destruction of periodontal tissue. Periodontal pathogens, such as *P. gingivalis* and *Aggregatibacter actinomycetemcomitans* (previously *Actinobacillus actinomycetemcomitans*), produce matrix metalloproteinases (MMPs) and exhibit collagenase activity.[20] MMPs, such as

Table 2.

Parameter Estimates From Simple Linear Regression Models Evaluating Intake of Green Tea in Relation to Periodontal Parameters

	Dependent Variable Mean PD (mm)			Dependent Variable Mean Clinical AL (mm)			Dependent Variable BOP (%)		
Independent Variable	Coefficient	SE	*P* Value	Coefficient	SE	*P* Value	Coefficient	SE	*P* Value
Intake of green tea (cups/day)	–0.034	0.011	0.002	–0.046	0.015	0.002	–0.84	0.28	0.002
Intercept	2.65	0.047	<0.001	3.21	0.062	<0.001	20.70	1.14	<0.001

R^2 for mean PD = 0.010, for mean clinical AL = 0.010, and for BOP = 0.010.

Table 3.

Parameter Estimates From Stepwise Multivariate Linear Regression Models Evaluating Each Independent Variable in Relation to Periodontal Parameters

	Dependent Variable Mean PD (mm)			Dependent Variable Mean Clinical AL (mm)			Dependent Variable BOP (%)		
Independent Variables	Coefficient	SE	*P* Value	Coefficient	SE	*P* Value	Coefficient	SE	*P* Value
Intake of green tea (cups/day)	–0.023	0.011	0.037	–0.028	0.013	0.035	–0.63	0.27	0.021
Smoking habit (pack-years)	0.008	0.001	<0.001	0.013	0.002	<0.001	0.096	0.035	0.006
Toothbrushing frequency (times/day)	–0.072	0.031	0.021				–3.04	0.79	<0.001
Teeth (n)	–0.056	0.008	<0.001	–0.12	0.011	<0.001	–0.65	0.21	0.002
Intercept	4.19	0.26	<0.001	6.01	0.29	<0.001	46.24	6.52	<0.001

R^2 for mean PD = 0.103, for mean clinical AL = 0.193, and for BOP = 0.048.

collagenases and gelatinases, break down the collagen and gelatin that make up the extracellular matrix of periodontal tissue, and MMP activity plays an important role in the pathogenesis and progression of periodontal disease. When periodontal pathogens live on local periodontal tissue, fibroblasts and macrophages produce several cytokines, including interleukin-1 and -6 and tumor necrosis factor-alpha, as mediators of the inflammatory response and immune reaction.[21] These cytokines play a direct role in the destruction of periodontal tissue and encourage fibroblasts and macrophages in periodontal tissue to enhance the production and activation of MMPs, resulting in the progressive destruction of periodontal tissue.[22] A study[13] showed that green tea catechin, EGCg, and ECg inhibit the activity of *P. gingivalis*–derived collagenase. In addition, EGCg inhibited osteoclast formation in a coculture of primary osteoblastic cells and bone marrow cells,[15] and it induced the apoptotic cell death of osteoclast-like multinucleated cells in a dose-dependent manner.[23] Previous studies[10,11] suggested that green tea catechin has a preventive effect against the development of cancer and cardiovascular disease, and the effect has been ascribed to the antioxidative mechanisms of catechin.[24,25] Oxidative stress plays an important role in the pathogenesis of periodontal disease, as well as many other disorders,[26,27] and it is believed that antioxidants can defend against inflammatory diseases.[26] Vitamin C is a well-known antioxidant,[28] and reports[5,29] have shown a significant relationship between vitamin C deficiency and periodontal breakdown. In addition, a recent animal study[30] showed that the oral administration of vitamin C prevented alveolar bone resorption by decreasing oxidative damage to periodontal tissue. Therefore, similar mechanisms might be involved in the effects of the intake of green tea.

Smoking habit and the frequency of toothbrushing, which are important lifestyle factors for periodontal

disease, were significantly associated with periodontal parameters and were associated with the intake of green tea in the bivariate analyses. However, when we entered the green tea intake and these factors simultaneously as independent variables into a multivariate regression model whose dependent variable was an index of periodontal disease, the intake of green tea was significantly associated with each periodontal parameter, independent of other variables. This shows that the relationship between the intake of green tea and periodontal disease is independent of other confounding factors.

The correlation coefficients in this study were generally small, suggesting that it is difficult to explain periodontal disease using only a few variables, because periodontitis is a multifactorial disease. The sample size in our study was sufficiently large to show the statistical significance of the relationship between the intake of green tea and periodontal disease, but the factors considered in this study were not sufficient to account for periodontal disease. Although a number of previous studies suggested that the intake of food and nutrients, such as dairy products,[8,9] whole grain,[7] fiber,[7] and vitamin C,[5] may affect the prevalence of periodontal disease, we did not examine the intake of foods and supplements other than green tea. Further studies including a dietary survey are necessary to identify other important confounders that explain the relationship between periodontal disease and the explanatory variables. Our periodontal examination at the mesio-buccal and mid-buccal sites of each tooth may have led to bias because we did not examine the periodontal condition at six sites per tooth. In some studies[31,32] that have examined the reproducibility and validity of dietary questionnaires, reasonable levels of reproducibility and validity were observed for the intake of tea. Nevertheless, because we did not assess the validity and reliability of our self-administered questionnaire, a bias derived from measurement errors may have affected the study results. The study design was based on a cross-sectional model, so the results cannot establish whether the regular intake of green tea has a beneficial effect on periodontal disease. Longitudinal studies of the relationship between the continued intake of green tea and periodontal disease are required to strengthen the interrelation. In addition, because our study subjects were males in their fifties, studies of both genders and a wide range of ages are needed to generalize the relationship between the intake of green tea and periodontal disease.

CONCLUSIONS

The present study suggests that there is a modest inverse association between the daily intake of green tea and periodontal disease. Drinking green tea at meals and breaks is a relatively easy habit to maintain, and drinking green tea as frequently as possible may help to maintain a healthy periodontium. However, because the observed relationship between the daily intake of green tea and periodontal disease was weak, the application of concentrated green tea components, such as catechin, may be expected to have a more beneficial effect on the periodontal condition.

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