Association Between Periodontal Disease and Metabolic Syndrome

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Abstract

Objectives: *Metabolic syndrome is a complex medical disorder characterized by visceral fat-type obesity involving hypertension, and abnormal glucose and lipid metabolism. The objective of this study was to investigate the relationship between periodontal disease and components of metabolic syndrome (obesity, lipid abnormality, hypertension, and hyperglycemia) in industrial workers of a single company in Tokyo, Japan.* ***Methods:*** *The study subjects consisted of 2,478 adult employees (2,028 men and 450 women; mean age: 43.3 years). The association between the presence of periodontal pockets and components of metabolic syndrome was investigated cross-sectionally using multiple logistic regression analysis, odds ratios (ORs), and 95 percent confidence intervals (CIs).* ***Results:*** *Body mass index, blood pressure, triglycerides, fasting blood glucose, and hemoglobin A1c (HbA1c) were significantly elevated ($P < 0.05$) in patients with periodontal pockets of 4 mm or more. We found that the OR of the presence of periodontal pockets adjusted for age, gender, and smoking habit was 1.8 (96 percent CI = 1.4-2.3) when the subjects with two positive components and without positive component were compared. And it was 2.4 (96 percent CI = 1.7-2.7) when the subjects with three or four positive components and without positive component were compared.* ***Conclusions:*** *Our findings suggest an association between periodontal disease and metabolic syndrome in Japanese workers between the ages of 20 and 60 years.*

Key Words: periodontal disease, metabolic syndrome, hypertension, triglycerides, body mass index, epidemiology

Introduction

Metabolic syndrome is a complex collection of symptoms thought to arise from a visceral fat-type obesity involving hypertension, and abnormal glucose and lipid metabolism. Preventing metabolic syndrome is of high medical importance because the presence of multiple risk factors increases the risk of developing cardiovascular disease (1,2). Numerous studies have linked periodontal disease to several serious risk factors of metabolic syndrome, including type 2 diabetes (3,4), obesity among community residents (5,6), lipid abnormalities in both patients with periodontal disease (7-11) and community residents (12), and elevated blood pressure levels (13). Although many studies have related periodontal disease to the disease states and comorbidities comprising metabolic syndrome, only one performed in a community of 40- to 79-year-old female residents has investigated this association comprehensively (14).

Periodontitis has been reported in 5.1 percent of males and females aged 15 to 19 years (15), and metabolic syndrome in 9.0 and 4.9 percent of teenage boys and girls, respectively (16). These findings demonstrate that both disease states are not just diseases afflicting older age groups. Rather, adopting early preventive measures may be more crucial among the younger population to avoid chronic disease later in life. Moreover, at least one study has shown gender dimorphism between food ingestion and/or habitual cigarette smoking, and manifestation of metabolic syndrome symptoms (17).

Thus, we elected to include both males and females (young and older) in our study population to investigate the association between periodontal disease and metabolic syndrome. Shimazaki *et al.* (14) reported that if the participants had more of the components of metabolic syndrome, the risk of periodontal disease tended to increase according to the number of the components. In this study, the association between periodontal disease and the components of metabolic syndrome, singly and in combination, was investigated in male and female industrial workers in their 20s to 50s.

Methods

Subjects. This study was approved by the ethics committee of Nihon University School of Dentistry. The study subjects are 2,478 employees (2,028 men and 450 women; mean age: 43.3 years, range = 24-60 years) of a household product company in Tokyo, Japan (name withheld for privacy considerations). The subjects underwent both periodical medical and dental checkups in 2006 and consented to the study.

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Of all the employees, 99.9 percent underwent systemic medical checkups, 82.8 percent had dental examinations, and 82.8 percent received both checkups.

Examinations for Periodontal Disease. Evidence of periodontal disease was assessed according to the World Health Organization Community Periodontal Index (CPI) criteria (18). To determine the CPI measurements, dental hygienists examined 10 representative teeth in six sextants under the supervision of dentists. The subjects were divided into two groups: one comprising individuals with CPI codes of 2 or lower (without a periodontal pocket: 1,837 subjects, accounting for 74.1 percent of all subjects) and the other group comprising individuals with at least one sextant of CPI codes of 3 or higher (with a periodontal pocket of 4 mm or more: 641 subjects, accounting for 25.9 percent of all subjects).

Systemic Checkup. The blood pressures of the participants were measured with an automatic hemomanometer while the patients were in sitting positions. Blood samples were collected from an arm vein in the morning before the subjects had eaten, and the triglyceride, high density lipoprotein (HDL) cholesterol, total cholesterol, fasting blood glucose, and hemoglobin A1c (HbA1c) levels were measured from these samples. To calculate overall obesity, the body mass indices (BMIs) were calculated from the heights and body weights of each participant. Together, these six test values were regarded as components comprising a diagnosis of metabolic syndrome.

The test values of the three components of blood pressure, hypertension, and hyperglycemia were based upon definition and diagnostic criteria of metabolic syndrome in Japan (19,20): a 130-mmHg or higher systolic or 85 mmHg or higher diastolic blood pressure equated as positive for hypertension; 150 mg/dL or higher triglycerides, or less than 40 mg/dL HDL cholesterol, was considered as positive for lipid abnormality; and 110 mg/dL or higher fasting blood glucose was deemed positive for hyperglycemia. Regarding obesity, a BMI of 25 or higher was regarded as positive for metabolic disorder. Besides four components of the above-mentioned metabolic syndrome, total cholesterol and HbA1c were also measured as diagnostic components and HbA1c of 5.5 or higher was regarded as positive for the presence of metabolic disorder (20).

Lifestyle Survey. The occurrence of a cigarette smoking habit was surveyed by a self-administered questionnaire at the time of the medical evaluations whether it is smoking now or not.

Statistical Analysis. Differences in the means and distributions of the individual components of metabolic syndrome were evaluated by Student's *t*-tests and Pearson's χ^2 tests. The association between the presence of periodontal pockets and each component of metabolic syndrome was investigated by multiple logistic regression analysis. In addition, the association between the presence of periodontal pockets and number of components of metabolic syndrome was investigated as well as the above-mentioned. And the odds ratios (ORs) and 95 percent confidence intervals for prognostic determination were calculated. Statistical analyses were performed with JMP (SAS Institute, Tokyo, Japan), with $P < 0.05$ set as the level of significance.

Results

The Presence of Periodontal Pockets and Statistical Comparisons for Determining Metabolic Syndrome Propensity. As shown in Table 1, we divided the subjects

Table 1
Mean Values of Components of Metabolic Syndrome in Subjects with and without Periodontal Pockets and the Characteristics of Subjects

Index of metabolic syndrome and characteristics of subjects	Values: Mean ± SD		Significance of difference
	Without pocket (n = 1,837)	With pocket (n = 641)	
BMI	22.9 ± 3.1	24.0 ± 3.1	**
Systolic blood pressure (mmHg)	117.8 ± 16.0	122.6 ± 17.2	**
Diastolic blood pressure (mmHg)	75.2 ± 12.1	79.3 ± 12.2	**
Triglycerides (mg/dL)	102.2 ± 94.9	126.9 ± 102.3	**
HDL cholesterol (mg/dL)	63.5 ± 15.3	60.2 ± 14.8	**
Total cholesterol (mg/dL)	200.8 ± 32.7	208.2 ± 34.0	**
Fasting blood glucose (mg/dL)	91.6 ± 13.4	98.3 ± 20.6	**
HbA1c (%)	5.1 ± 0.5	5.3 ± 0.8	**
Age (years)	41.6 ± 9.9	48.0 ± 9.3	**
Gender (sex ratio)	Male 79.2% Female 20.8%	Male 89.4% Female 10.6%	**
Smoking rate	29.3%	40.1%	**

** $P < 0.01$.
BMI, body mass index; HbA1c, hemoglobin A1c; HDL, high density lipoprotein; SD, standard deviation.

Table 2
Association Between the Presence of Periodontal Pockets and Components of Metabolic Syndrome

Component of metabolic syndrome		Number of subjects (%) Without pocket (n = 1,837)	With pocket (n = 641)	Odds ratio† (95% CI)
BMI	<25	1,431 (77.9)	418 (65.2)	1.0
	≥25	406 (22.1)	223 (34.8)	1.6 (1.3-1.9)**
Blood pressure	<130 and <85	1,287 (70.0)	364 (56.8)	1.0
	≥130 or ≥85	549 (30.0)	277 (43.2)	1.2 (1.0-1.5)**
Triglycerides	<150	1,542 (84.1)	475 (74.1)	1.0
	≥150	292 (15.9)	166 (25.9)	1.3 (1.0-1.7)*
HDL cholesterol	≥40	1,777 (96.9)	600 (93.6)	1.0
	<40	57 (3.1)	41 (6.4)	1.6 (1.0-2.6)
Fasting blood glucose	<110	1,736 (94.7)	550 (85.8)	1.0
	≥110	98 (5.3)	91 (14.2)	1.9 (1.4-2.7)**
HbA1c	<5.5	1,691 (92.3)	517 (80.7)	1.0
	≥5.5	142 (7.7)	124 (19.3)	2.0 (1.5-2.6)**

* $P < 0.05$.
** $P < 0.01$.
† Adjusted for age, gender, and smoking habit.
BMI, body mass index; CI, confidence interval; HDL, high density lipoprotein; HbA1c, hemoglobin A1c.

Table 3
Association Between the Presence of Periodontal Pockets and Positivity for Components of Metabolic Syndrome

Number of positive components of metabolic syndrome	Rate of subjects (%)	Odds ratio† (95% CI)
0	48.0	1.0
1	27.1	1.3 (1.0-1.6)
2	16.7	1.8 (1.4-2.3)**
3 or 4	8.2	2.4 (1.7-2.7)**

** $P < 0.01$.
† Adjusted for age, gender, and smoking habit.
CI, confidence interval.

into two groups: those with and without periodontal pockets. The mean values of the metabolic syndrome components, characteristics of the subjects, and smoking rates are also shown for each group (Table 1). All variables were determined to be significantly different between the two groups ($P < 0.05$; Table 1).

Association Between the Presence of Periodontal Pockets and Components of Metabolic Syndrome. The ORs of the positive components of metabolic syndrome for the presence of periodontal pockets (adjusted for age, gender, and smoking habit) were: BMI = 1.6; blood pressure = 1.2; triglycerides = 1.3; fasting blood glucose = 1.9; and HbA1c = 2.0. All of these components demonstrated significantly higher ORs ($P < 0.05$; Table 2).

Association Between the Presence of Periodontal Pockets and the Number of Positive Components of Metabolic Syndrome. Nakamura *et al.* (21) attached importance to cases that corresponds to two components or more in four components of metabolic syndrome. The subjects were classified into two groups according to the number of metabolic syndrome components for which they tested positive or negative, respectively, and by their ORs adjusted for age, gender, and smoking habits. These two groups were compared statistically, and the results are shown in Table 3. The ORs in subjects with two and three or four positive metabolic syndrome components was 1.8 and 2.4, respectively, demonstrating that the OR increased proportionally (P-value < 0.01, Cochran–Armitage trend test) with an increase in the number of positive components.

Since the presence of periodontal pockets was also associated with age, gender, and smoking habit, we also performed an analysis comparing these variables between the two groups (Tables 4, 5, and 6, respectively). On the smoking habit- and gender-adjusted comparisons between the subjects in their 20s and 30s and in their 40s and 50s, the OR for the presence of periodontal pockets increased significantly as the number of positive components of metabolic syndrome increased (in their 40s and 50s), but no significant association was noted between the presence of periodontal pockets and the number of positive components among subjects in their 20s and 30s. Regarding smoking habit- and age-adjusted comparisons between genders, the OR increased significantly as the number of positive components increased in the men, but no significant association was noted among the women.

For the age- and gender-adjusted comparisons between subjects with

Table 4
Association Between the Presence of Periodontal Pockets and Positivity for Components of Metabolic Syndrome by Age

Number of positive components of metabolic syndrome	Rate of subjects (%)		Odds ratio† (95% CI)	
	20s and 30s	40s and 50s	20s and 30s	40s and 50s
0	69.1	36.0	1.0	1.0
1	20.7	30.7	1.3 (0.8-2.0)	1.3 (1.0-1.7)
2	7.9	21.7	1.3 (0.3-1.7)	2.0 (1.5-2.7)**
3 or 4	2.3	11.6	1.5 (0.4-4.1)	2.6 (1.8-3.7)**

** $P < 0.01$.
† Adjusted for gender and smoking habit.
CI, confidence interval.

Table 5
Association Between the Presence of Periodontal Pockets and Positivity for Components of Metabolic Syndrome by Gender

Number of positive components of metabolic syndrome	Rate of subjects (%)		Odds ratio† (95% CI)	
	Male	Female	Male	Female
0	41.1	79.7	1.0	1.0
1	29.8	14.9	1.3 (1.0-1.6)	1.1 (0.5-2.1)
2	19.3	4.5	1.8 (1.3-2.3)**	1.8 (0.6-4.8)
3 or 4	9.8	0.9	2.5 (1.7-3.3)**	1.7 (0.1-13.9)

** $P < 0.01$.
† Adjusted for age and smoking habit.
CI, confidence interval.

and without smoking habit, the OR increased significantly as the number of positive components increased, regardless of the presence/absence of a smoking habit.

Discussion

In this study, we investigated the association between periodontal disease and the components of metabolic syndrome, singly and in combination, in male and female industrial workers in their 20s to 50s.

The adjusted ORs for the presence of periodontal pocket in the positive subjects were high for BMI, blood pressure, triglycerides, fasting blood glucose, and HbA1c compared with those in the negative subjects, and showed a significant association with the presence of periodontal pockets. The ORs rose markedly as the number of positive components of metabolic syndrome increased, showing that the risk of periodontal disease was high in subjects with many positive metabolic syndrome components.

For the analysis of the individual components of metabolic syndrome, the OR was higher in subjects who were positive for fasting blood glucose and Hb1Ac levels compared with those positive for BMI, blood pressure, and triglycerides, showing a strong association of fasting blood glucose and Hb1Ac with periodontal disease. The association of diabetes with periodontal disease is well known (22), and the adipose tissue-derived inflammatory cytokine, tumor necrosis factor alpha (TNF-α) present in type 2 diabetes is considered to enhance insulin resistance, which aggravates glucose control and elevates HbA1c (23). In contrast, macrophage-derived TNF-α is produced in patients with periodontal disease (3). The ORs of fasting blood glucose and HbA1c for the presence of periodontal pockets were higher than those of the other components, suggesting the involvement of TNF-α in these associations.

Elevated blood pressure and triglyceride levels were associated with periodontal disease in our study, but not in the study reported by Shimazaki *et al.* (14). This discrepancy may have been due to differences in the living environments, ages, and genders of the subjects (22). Moreover, periodontal tissue was examined in one-fourth of the teeth in both the upper and lower jaws, and a 2-mm or greater average depth was regarded as a periodontal pocket in the study by Shimazaki *et al.* (14). In our study, representative teeth from each of the six sextants (the "10-teeth" method) were examined, and a 4-mm or greater depth was regarded as a periodontal pocket. These differences in the number of teeth examined and conversions to the binary dependent variable may also have led to the different associations among the subjects of the two studies.

Previous studies performed in patients with periodontal disease investigated the relationship between periodontal disease, and triglyceride levels (11) and hypertension (13), and suggested distinct associations. In our study, the association between HDL cholesterol and periodontal pockets was not significant ($P > 0.05$), but the OR was 1.6 ($P = 0.0516$), showing a tendency toward an association. Shimazaki *et al.* (14) also reported the similar finding that periodontal disease was associated with HDL cholesterol. Based on the above findings, several measurable components including obesity, hyperglycemia, hypertension, and lipid abnormality may be individually associated with periodontal disease in these workers.

The risk of periodontal disease was high in subjects with many of the documented positive components of metabolic syndrome. In the study performed in women aged 40 to 79 years by Shimazaki *et al.* (14), periodontal disease and the number of positive components of metabolic syndrome were associated, as they were in our study performed on both adult male and female employees in their 20s to 50s. Metabolic syndrome is a multiplex disorder combining multiple risk factors (obesity,

Table 6
Association Between the Presence of Periodontal Pockets and Positivity for Components of Metabolic Syndrome by Smoking Habit

Number of positive components of metabolic syndrome	Rate of subjects (%)		Odds ratio† (95% CI)	
	With smoking habit	Without smoking habit	With smoking habit	Without smoking habit
0	41.8	51.0	1.0	1.0
1	28.8	26.3	1.1 (0.8-1.7)	1.3 (1.0-1.7)
2	19.6	15.3	1.9 (1.2-2.9)**	1.7 (1.2-2.4)**
3 or 4	9.8	7.4	2.9 (1.7-4.9)**	2.1 (1.4-3.2)**

** $P < 0.01$.
† Adjusted for age and gender.
CI, confidence interval.

hyperglycemia, hypertension, and lipid abnormality), which in combination or independently, can lead to cardiovascular disorders. The findings of this study suggest that the positive metabolic components complex also predict periodontal disease in our statistical model.

Since age, gender, and smoking habits were strongly associated with the presence of periodontal pockets, we performed further analyses on these variables. In the analysis by age, the OR increased significantly as the number of positive components of metabolic syndrome increased among subjects in their 40s and 50s. The OR calculated for those participants in their 20s and 30s was 1.3 to 1.5, which was nonsignificant ($P > 0.05$). According to the results of the 2006 National Health and Nutrition Survey in Japan (24) reported by the Ministry of Health, Labour and Welfare, the total number of persons strongly suspected of having metabolic syndrome (85 cm or greater abdominal circumference with two or more positive components) and those in the preliminary group (85 cm or greater abdominal circumference with one positive index) was 52.2 percent in those in their 50s but only 11.4 and 27.7 percent in those in their 20s and 30s, respectively. Similarly, two or more components were positive in 36.6 percent in those in their 50s but only 13.6 percent in those in their 20s and 30s in our study, suggesting that this difference led to the absence of a significant difference in those in their 20s and 30s.

However, when the results of the 2005 (25) and 2006 (24) National Health and Nutrition Surveys in Japan were compared, the total numbers of persons strongly suspected of having metabolic syndrome and those in the preliminary group were markedly higher in 2006 in all generations, and the rate increased from 24.4 to 27.7 percent in those in their 30s. The OR increased with a concomitant increase in the number of positive components of metabolic syndrome, even among subjects in their 20s and 30s, indicating that the association between periodontal disease and metabolic syndrome cannot be ruled out even in a young population. Moreover, this percentage may increase in this population without radical changes in diet and lifestyle, as obesity can aggravate or contribute to the onset of chronic conditions. The prevention of periodontal disease and metabolic syndrome in young populations may become an important task.

In our analysis by gender, the OR for the presence of periodontal pockets increased significantly concomitantly with the increase in the number of positive metabolic syndrome components in the men, thus clarifying the association of metabolic syndrome with periodontal disease in this group. In contrast, the female study group showed no significant association with metabolic syndrome, although a tendency was noted. Our findings did not corroborate those of Shimazaki *et al.* (14), which may have been attributable to the younger ages and smaller sample sizes comprising our groups. In addition, the OR became significantly elevated as the number of positive components of metabolic syndrome increased regardless of the presence or absence of smoking habit, suggesting that periodontal disease was associated with metabolic syndrome.

Our data suggest a close association between periodontal disease and metabolic syndrome in industrial workers in their 20s to 50s. Considering that the prevalence of metabolic syndrome is increasing, it is important for workers, including young adults, to undergo regular systemic and oral checkups and maintain a healthy oral condition.

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