# Periodontal Disease and Coronary Heart Disease

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**Background:** Several epidemiological studies have demonstrated an association between periodontal disease and coronary heart disease (CHD). The association could be a result of confounding by mutual risk factors. The present study was undertaken in a Danish population to reveal the significance of common risk factors.

**Methods:** The investigation was conducted as a case-control study comprising 250 individuals: 110 individuals with verified CHD from a Department of Cardiovascular Medicine and 140 control individuals without CHD from the Copenhagen City Heart Study. Information on diabetic status, smoking habits, alcohol consumption, physical activity, school attendance, household income, body weight and height, triglyceride, and serum cholesterol was obtained. Full-mouth probing depth (PD), clinical attachment loss (CAL), bleeding on probing (BOP), and alveolar bone level (ABL) on radiographs were registered. ABL was stratified into ABL1 = ABL ≤2 mm; ABL2 = ABL >2 to ≤4 mm; and ABL3 = ABL >4 mm. Multiple logistic regression models with stepwise backward elimination were used allowing variables with $P<0.15$ to enter the multivariate analysis.

**Results:** The CHD group had a significantly lower outcome with respect to PD, BOP, CAL, and ABL. For participants <60 years old, only risk factors such as smoking and diabetic status entered the multivariate analysis. For the ABL3 group, there was a significant association with CHD for participants <60 years old, the odds ratio being 6.6 (1.69 to 25.6). For participants ≥60 years old, there was no association.

**Conclusions:** The present study showed a positive association between periodontal disease and CHD in agreement with several other studies. The association was highly age dependent and could only be attributed to diabetes and smoking to some extent. *J Periodontol 2006;77:1547-1554.*

**KEY WORDS**

**Case-control study; coronary heart disease; periodontal disease; risk factors.**

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Within the past decade, epidemiological studies have repeatedly shown an association between periodontal disease and coronary heart disease (CHD). Periodontal disease and CHD are widespread conditions, and, therefore, an association between them is an important scientific subject from a preventive point of view. Several studies have been conducted using cohort, cross-sectional, or case-control designs with varying conclusions on the strength of the association as reviewed by Holmstrup et al.[1] Most of the results reporting a lack of association between periodontal disease and CHD are from prospective studies.

In earlier studies, the measurement of periodontal disease has ranged from self-reported periodontal disease, partial recording of attachment, the number of teeth left, and the Russell plaque index to clinical attachment loss (CAL) and alveolar bone level (ABL), but no studies have been based on full-mouth registration of CAL and registration of ABL to our knowledge.

It has been suggested that the spread of bacteria and bacterial products from the periodontal lesion to the bloodstream may contribute to arteriosclerosis and CHD.[2,3] However, whether an association between periodontal disease and CHD could be causal is still uncertain. Another explanation for the observed association could be that the two disease entities share common risk factors.

For CHD, several modifiable and non-modifiable factors, such as elevated

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serum lipids, smoking, diabetes, age, male gender, low socioeconomic status, hypertension, dyslipidemias, and alcohol consumption,[4,5] are generally accepted risk factors. Studies have also linked several of these risk factors to periodontal disease, including smoking, diabetes, age, male gender, and low socioeconomic status. Recently, studies have even shown that dyslipidemias may be related to periodontal disease,[6,7] and a few studies have shown that alcohol consumption resulted in increased periodontal disease.[8]

In this study, we aimed to test the hypothesis that a high prevalence of periodontal disease among CHD patients could be explained, at least in part, by mutual risk factors.

## MATERIALS AND METHODS

The Scientific Ethical Committee of Copenhagen and Frederiksberg approved the study, and informed written consent was obtained from all participants.

### *Study Population*

The study was designed as a case-control study. It involved 110 consecutive CHD patients (mean age: 65 years; 70% male) diagnosed at the Department of Cardiology, Bispebjerg University Hospital. After discharge, they were invited to participate in the study. From the Copenhagen City Heart Study, Epidemiologic Research Unit, Bispebjerg University Hospital, 140 people without CHD (mean age: 62.6 years; 60% male) were recruited consecutively to match the age and gender distribution of CHD patients as closely as possible. Enrollment started in May 2002 and ended in June 2003. Participants with chronic inflammatory disease, human immunodeficiency virus (HIV) infection, a history of organ transplant, or cancer treatment 6 months before examination were excluded during the selection period.

To confirm the diagnoses of individuals with CHD, hospital case records were examined. A total of 42 individuals had clear ischemic changes on the electrocardiogram (ECG). Among the rest of the CHD cases, 17 had been subjected to coronary artery bypass graft surgery, 34 to percutaneous transluminal coronary angioplasty (PTCA), and 17 had signs of coronary ischemia from coronary angiography. Sixty patients with CHD had their first CHD event a maximum of 12 months prior to the examination. No ischemic changes were observed on the ECG of control individuals.

### *Medical Examination*

All 250 participants had a medical examination in the Copenhagen City Heart Study involving a questionnaire concerning symptoms and diseases, familial dispositions, education and socioeconomic status, smoking and drinking habits, eating habits, physical activity, medication, and previous contacts with the health care system. Smoking was recorded as the type of tobacco, amount used, and duration of smoking period in years. Height and weight were measured. A resting ECG was taken, and an echocardiography was performed. Arm blood pressure was measured with the subject seated, a blood sample was taken, and total serum cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and triglyceride were measured. Any use of medicine was registered. The methods have been described in detail previously.[9]

**Table 1.**

**Univariate Association Between Coronary Heart Disease and Oral Variables**

| Oral Variable | CHD (N = 110) | Non-CHD (N = 140) | P* |
|---|---|---|---|
| ABL (mm) | 3.6 (1.8) | 2.8 (1.4) | <0.001 |
| CAL (mm) | 3.7 (1.5) | 2.9 (1.3) | <0.001 |
| PD (mm) | 2.9 (0.9) | 2.5 (0.6) | 0.002 |
| BOP (%) | 38.4 | 30.7 | 0.015 |
| NUM | 17.9 (9.6) | 20.8 (8.7) | 0.015 |
| Edentulous (%) | 11.6 | 7.3 | 0.236 |
| ABL1 (%) | 16.5 | 35.1 | 0.003 |
| ABL2 (%) | 52.5 | 46.9 | |
| ABL3 (%) | 31.0 | 18.0 | |

Values presented are mean (SD) or frequency in percent.
NUM = number of teeth.
* Student $t$ and $\chi^2$ tests.

### *Oral Examination*

A dentist (KG) performed the oral examination at a dental unit in the Department of Cardiology, Bispebjerg University Hospital. Periodontal registrations were performed by a trained periodontist. Information on dental hygiene procedures was registered, and a clinical examination was carried out: probing depth (PD), recession, and bleeding on probing (BOP) were registered by the use of a periodontal probe on six sites of all existing teeth excluding third molars. An indirect measurement of CAL was calculated on the basis of PD and the level of the gingival margin. Six intraoral radiographs were taken: two vertical bitewings on each side and two periapical radiographs of the incisors of both jaws.

The radiographs were scanned and digitized.§ Two blinded measurements of ABL were made on each tooth present, excluding third molars. ABL was

§ Epson expression 1680 pro, Hemel Hempstead, U.K.

**Table 2.**

## Univariate Association Between Coronary Heart Disease and Cardiovascular Risk Factors

| Risk Factors | CHD (N = 110) | Non-CHD (N = 140) | P* |
|---|---|---|---|
| Diseases | | | |
| Diabetes, self-reported (%) | 17.3 | 3.6 | <0.001 |
| Lifestyle factors | | | |
| Smoking >40 pack years (%) | 20.6 | 14.1 | |
| Smoking >20 to ≤40 pack years (%) | 34.0 | 20.3 | 0.025 |
| Smoking >0 to ≤20 pack years (%) | 20.6 | 29.7 | |
| Alcohol, daily consumption (%) | 33.6 | 39.3 | 0.358 |
| Physical activity, <2 hours weekly (%) | 17.3 | 8.6 | 0.038 |
| Socioeconomic factors | | | |
| School attendance (years) | 8.8 (1.9) | 9.5 (2.0) | 0.005 |
| Household income, small† (%) | 42.7 | 33.6 | 0.138 |
| Other characteristics | | | |
| Male (%) | 70.0 | 60.0 | 0.101 |
| Age (years) | 65.2 (11.5) | 62.6 (10.5) | 0.070 |
| Clinical and paraclinical measurements | | | |
| BMI (kg/m$^2$) | 27.1 (4.7) | 26.7 (4.2) | 0.488 |
| Blood pressure, systolic (mmHg) | 134.9 (22.6) | 141.1 (21.6) | 0.027 |
| Triglyceride (mmol) | 1.7 (0.8) | 1.5 (0.9) | 0.131 |
| HDL-c (mmol) | 1.3 (0.5) | 1.5 (0.4) | 0.002 |
| LDL-c (mmol) | 2.8 (1.0) | 3.6 (1.0) | <0.001 |

Values presented are mean (SD) or frequency in percent.
BMI = body mass index.
* Compared to non-smoking group, using the Student *t* test for continuous variables and the $\chi^2$ test for categorical variables.
† Individuals with a household income less than <200,000 Danish kroner yearly.

defined as the distance between the cemento-enamel junction (CEJ) to the most apical level of the alveolar crest or, in cases of an evident infrabony pocket, to the bottom of the defect. If the point to mark the alveolar crest could not be decided, the site of the tooth was omitted.

If a crown or filling covered the CEJ, an estimated placement of CEJ was marked using the CEJ level of adjoining teeth. If no CEJ could be found, or if it was covered by a neighboring tooth, the site of the tooth was excluded. The measurement was carried out blinded on the digitized radiograph with an image-handling program‖ using a mouse-driven cursor. Prior to the measurement of ABL, measures of agreement were made by the use of κ statistics. The simple κ values were 0.66, and the weighted values were 0.84, which were regarded as acceptable.

ABL was stratified into three groups: in the ABL1 group, the means were ≤2 mm; in the ABL2 group, the means were >2 to ≤4 mm; and in the ABL3 group, the means were >4 mm. The same stratification was made for CAL. The means were calculated based on all measured sites from each individual.

### *Statistical Methods*

Statistical analysis was performed using statistical software.¶

The Student *t* test was used for continuous variables, and the Mann-Whitney rank sum test was used if they did not meet the demand for variance homogeneity and normality. All oral variables were tested using both parametric and non-parametric analyses; all analyses were in agreement. With more than two groups, the Kruskal-Wallis test was used. Differences between groups for categorical variables were analyzed using $\chi^2$ distribution. The Spearman correlation for continuous variables and the Kendall τ B correlation test for ordinal variables were used when testing for a trend. A two-sided 5% level of significance was used in statistical analyses.

Multiple logistic regression models with stepwise backward elimination were used allowing variables with $P < 0.15$ to enter the multivariate analysis. Odds ratios were calculated with a confidence interval of 95%.

## RESULTS

Table 1 shows periodontal variables characteristic within the CHD and non-CHD groups. The CHD group had a significantly poorer outcome with respect to all periodontal variables ($P < 0.05$) except for the proportion of edentulous individuals (25 of all participants) where the difference was insignificant.

A comparison of risk factors (Table 2) showed significant differences in self-reported diabetes, physical activity level, and years of school attendance between the CHD and non-CHD groups. The distribution of smoking (pack years) in the CHD and non-CHD groups had an overall significant difference at $P = 0.025$. The differences seen in HDL-c, LDL-c, and blood pressure were found to be opposite to the expected values, so that the CHD group had lower values than the non-CHD group. HDL-c, LDL-c, triglyceride,

‖ DP-soft, version 3.2 for Windows, Olympus, Hamborg, Germany.
¶ SAS for PC, Statistical Analysis System, SAS Institute, Cary, NC.

**Table 5.**

## Odds Ratio (95% confidence limits) for Coronary Heart Disease According to ABL With Different Adjustment Criteria

| Logistic Regression With Forced Entry of Variables | | | |
|---|---|---|---|
| Group | ABL1 | ABL2 | ABL3 |
| All | | | |
| Crude odds ratio | 1 | 2.4 (1.21 to 4.73) | 3.7 (1.67 to 8.07) |
| Adjusted for | | | |
| 1) Age | 1 | 2.4 (1.13 to 4.97) | 3.6 (1.57 to 8.44) |
| 2) 1) + diabetes | 1 | 2.1 (0.96 to 4.41) | 3.4 (1.45 to 8.06) |
| 3) 2) + smoking >0 pack years | 1 | 1.7 (0.76 to 3.71) | 2.2 (0.87 to 5.61) |
| 4) 3) + school attendance >10 years | 1 | 1.6 (0.71 to 3.51) | 2.0 (0.77 to 5.08) |
| <60 years old | | | |
| Crude odds ratio | 1 | 3.8 (1.38 to 10.4) | 9.8 (2.77 to 34.9) |
| Adjusted for | | | |
| 1) Smoking >0 pack years | 1 | 3.1 (1.09 to 8.91) | 6.9 (1.80 to 26.8) |
| 2) 1) + diabetes | 1 | 2.4 (0.82 to 7.41) | 6.6 (1.69 to 25.6) |
| ≥60 years old | | | |
| Crude odds ratio | 1 | 1.3 (0.46 to 4.72) | 1.5 (0.44 to 3.56) |
| Adjusted for | | | |
| 1) Age | 1 | 1.0 (0.34 to 3.83) | 1.1 (0.34 to 3.00) |
| 2) 1) + diabetes | 1 | 0.9 (0.31 to 2.97) | 1.1 (0.30 to 3.74) |
| 3) 2) + smoking >0 pack years | 1 | 0.7 (0.18 to 2.74) | 0.8 (0.26 to 2.69) |

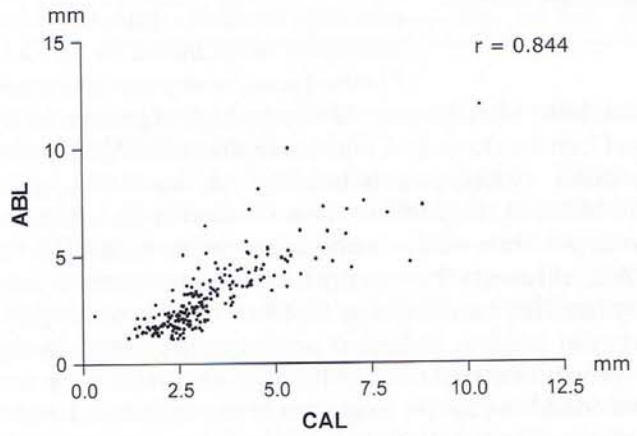


***Figure 1.***
*Correlation between ABL and CAL.*

(Table 5) among participants <60 years old indicates that a dose-response relationship between ABL and CHD may exist.

The biologically plausible explanation of the observed association between periodontal disease and CHD has been that chronic infections and associated inflammatory processes may be involved in the initiation and progression of atherosclerosis. Two pathways are suspected to be involved: a direct pathway where the periodontal bacteria invade the arterial wall[26,27] or an indirect pathway where bacterial products from the periodontal pocket exert a systemic effect on atherosclerosis development.[28,29] *Chlamydia pneumoniae* has also been linked with CHD, and it was proposed that infection with *C. pneumoniae* was a cause of CHD. However, recent meta-analysis rejects any strong association between infections with *C. pneumoniae* and CHD, although a modest association in a younger age group cannot be excluded.[30]

In our study, it is evident that periodontal disease and CHD share common risk factors, and smoking and diabetes could explain half of the observed associations between periodontal disease and CHD. Smoking and diabetes are known to induce changes in the microvascular function affecting the peripheral blood circulation.[31,32] The functional impairment of the microcirculation in smokers has been shown to affect the gingival tissue.[33] Furthermore, smoking and diabetes are known to be associated with a greater susceptibility to infections.[34,35] This is in agreement with the result of seroepidemiological studies showing that *C. pneumoniae* infections are more common in smokers.[36]

With a poor adjustment for smoking, a study could correlate periodontal disease to smoking-related diseases like chronic obstructive lung disease, lung cancer, and CHD.[37] These associations disappeared after relevant adjustment, including duration, amount, and type of smoking.[38] In the present study, available data on tobacco use enabled the calculation of pack years, and this variable was found to be associated with ABL and CHD (Tables 2 and 3). Despite the adjustment with smoking recorded as pack years, the association in the present study remained statistically significant.

## CONCLUSIONS

The present study has shown a positive association between periodontal disease and CHD in agreement with several other studies. The association was highly age dependent and could only be attributed to diabetes and smoking to some extent.

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