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Clinical Study

Clinically Classified Periodontitis and Its Association in Patients with Preexisting Coronary Heart Disease

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The aim of this retrospective study was to investigate possible associations between clinically classified periodontitis as determined by assessing its severity and diagnosed coronary heart disease in outpatients referred to a specialist clinic for neurosurgery treatment. A total of 2,912 individuals were clinically examined for periodontal disease experience by using probing pocket depth (PPD) and clinical attachment loss (CAL). Socioeconomic, oral health behaviour, and general health related information was collected by using a self-administered questionnaire. Statistical analysis of the questionnaire items was performed by using multivariate logistic regression analysis model. The results showed that the occurrence of hypertension (OR = 2.42, 95% CI = 1.52–3.84), smoking (OR = 1.97, 95% CI = 1.25–3.11), classified periodontitis (OR = 1.79, 95% CI = 1.15–2.77), and the high level of serum C-reactive protein (OR = 1.74, 95% CI = 1.05–2.89) were significantly associated with the presence of coronary heart disease. These observations strengthen the role of some of the traditional causative risk factors for coronary heart disease while a significant association was recorded between diagnosed coronary heart disease and clinically classified periodontitis which is considered as a risk factor for coronary heart disease.

1. Introduction

Cardiovascular diseases (CVD) and in particular coronary heart disease (CHD) represent a severe health condition and the main cause of mortality nowadays in industrialized societies. CHD is a multifactorial pathological condition and occurs as a result of genetic, environmental, and behavioral risk factors [1] while chronic inflammation has been implicated etiologically in CVD and CHD [2]. The genetic factors include age, gender, hypertension, diabetes mellitus, marked obesity, lipid metabolism, fibrinogen levels, and platelet P1 polymorphism [3–5]. The environmental and behavioral risk factors include diet, physical inactivity, stress, cigarette smoking, excessive alcohol consumption, socioeconomic status, chronic infections, use of nonsteroid anti-inflammatory drugs, and possible endothelial cell injury [4–7]. However, a significant proportion of CHD is not explained by the traditional risk factors [8].

Periodontitis is a complex chronic inflammatory disease, resulting in a loss of connective tissue and bone support of the teeth [9]. Previous studies have linked several risk factors to periodontitis including diabetes mellitus, smoking, age, gender, low socioeconomic status [10], dyslipidemias, and excessive alcohol consumption [9, 11], whereas the genetic basis of chronic periodontitis has been suggested by other investigations [12, 13]. In addition, periodontitis was associated with elevations of several markers of chronic inflammation [14], and because of evidence implicating chronic inflammation in the etiology of CHD, an etiologic relationship between periodontitis and CHD has been hypothesized [15].

Significant associations between periodontitis and CHD have been reported in previous case-control and cohort

studies [8, 10, 16–30], which are dependent on the severity of periodontal disease (PD) [10, 31]. This could be directly due to periodontal pathogens or their products on endothelial cells via transient bacteremia or indirectly due to products on the inflammatory response, central role in pathogenesis of CVD [32].

Beck et al. [33] presented a hypothesis suggesting that there could be an underlying inflammatory response trait that places individuals at high risk for developing PD and atherosclerosis. In addition, recent studies have shown that treatment of periodontitis reduces the serum concentration of inflammatory markers [34] and lipoproteins [21]. However, it remains controversial whether or not eliminating periodontal infections would contribute to the prevention of CHD [35].

Periodontitis and CHD share several risk factors, for example, smoking and diabetes mellitus [36], and this observation might be one of the explanations for the association between the two pathological conditions [37].

A recent study reported similarities in the spectrum of bacteria in the oral cavity and in coronary plaques, and both diseases are characterized by an imbalanced immune reaction and a chronic inflammatory process [13], while significant similarities also exist in the pathogenetic processes of CVD and periodontitis, including monocyte hyperresponsiveness [38], elevations in systemic levels of C-reactive protein [34], serum amyloid A (SAA) [39], and fibrinogen [40].

More recently, other reports focused on demonstrating that genetic factors influence biological processes involved in both diseases, representing a potential mechanism that may link periodontitis to CVD [41, 42] and could explain the positive association of these two pathological conditions [33]; however these factors remain unknown at this time.

On the other hand, a few studies, especially prospective ones, failed to demonstrate such an association between periodontitis and an increased risk of CHD [43–48].

Furthermore, the major issues that have been deemed responsible for the inconsistency of the findings are the different methods, criteria, and indices used to assess or define PD. This is mainly due to the fact that there is no uniform criteria to define PD or to measure the extent and severity of it [49].

Despite the large amount of studies present in the international literature, the exact mechanisms involved in this association are not fully understandable. It is also crucial to highlight that it is difficult to establish or not a cause-and-effect relationship between CVD and PD because of the long follow-up period and because PD is implicated in several phases of the formation, development, and rupture of the atherosclerotic plaque [50], and consequently its action is not observable [51].

CVD and periodontitis are widespread pathologic conditions, and therefore an association between them is an important scientific subject from a preventive point of view. For these reasons there has been strong interest in evaluating whether periodontitis is independently associated with CHD.

The aim of the current research was to investigate whether clinically classified periodontitis is associated with preexisting CHD in patients referred to a specialist clinic.

2. Material and Methods

2.1. Subject Population. The study sample consisted of 2,912 individuals, 1,360 males and 1,552 females, 40 to 70 years of age. All the participants were outpatients of a neurosurgery clinic of a military hospital in the capital of Greece, Athens. The mentioned hospital, 417-General Military Hospital of Athens-NIMTS, provides medical services to the whole population and military personnel were included as well.

All the outpatients completed a health questionnaire and underwent an oral clinical examination. The investigation was carried out between January and November 2012.

2.2. Selection Criteria. The selection criteria of the participants comprised age from 40 to 70 years old and a mean of 20 natural teeth, since large numbers of missing teeth could lead to over- or underestimate the examined variables and the possible associations that are under consideration.

None of the participants had received root planning procedure or periodontal treatment during the previous six months or receive prescription of systemic antibiotics or anti-inflammatory or other systemic drugs. These criteria were applied because of potential effects on the oral tissues. Individuals with diseases such as rheumatoid arthritis, acute infections, neoplasm, liver cirrhosis, and regular medication with general glucocorticoids were also excluded from the study, because of the possible potential confounding influences on the study parameters.

2.3. Questionnaire. Before the oral clinical examination all participants filled out a self-administered questionnaire that included variables such as age, gender, smoking status (active smokers/nonsmokers), and data regarding the general medical history of them with reference to medication and several chronic systemic disorders.

The basic criterion in order for an individual to be selected in the current study was the question if CHD was diagnosed by a medical doctor. In case of a positive response, the individual had to meet the following criteria in order to be included in the study: to have some degree of ischemic heart disease, to use calcium channel blockers (nifedipine or diltiazem), beta-blockers, and coumarin anticoagulants as prescribed treatment, and not to have any other relevant systemic pathological condition [52].

Hypertension and diabetes mellitus were determined in a similar manner; that is, if the diseases were diagnosed by a medical doctor.

In cases where the participants could not remember details of their medical history concerning the mentioned or other medical variables, the additional data was collected by their own personal medical file.

Medical biomarkers such as serum total cholesterol, triglycerides, high-density lipoprotein (HDL), and C-reactive protein (C-RP) were determined by laboratory tests for the whole individuals. Categorization of serum cholesterol, HDL-cholesterol, and triglycerides was based on the scientific statement of the American Heart Association (AHA) and American College of Cardiology (ACC) [53].

Tooth brushing was determined by the frequency of brushing: two or more times a day versus less or rarely. Incomes were classified into two categories: 0–1,000€ a month and 1,001€ a month and above. Similarly, education was classified into two categories: education in university/higher educational institutions and education in primary-elementary/high school.

2.4. Clinical Examination. The oral clinical examinations were performed at the neurosurgery clinic of the mentioned military hospital, using a conventional examination bed and illumination coming from a digital lens suitable for oral cavity examination by otolaryngologists. One well-trained and calibrated dentist performed the oral examinations.

The Clinical Measurements Concerned the Following Variables. On each, tooth clinical attachment loss (CAL) and probing pocket depth (PPD) were measured by a William's PCP 12 probe (PCP 10-SE, Hu-Friedy Mfg. Co. Inc., Chicago, IL, USA) at six sites per tooth (distofacial, facial, mesiofacial, distolingual, lingual, and mesiolingual) of all teeth except for the 3rd molars and remaining roots. The severity of periodontitis classified as follows [54]:

(a) severe periodontitis: ≥2 sites with interproximal CAL ≥4.0 mm not on the same tooth and ≥1 sites with interproximal PPD ≥5.0 mm,

(b) moderate periodontitis: ≥2 sites with interproximal CAL ≥4.0 mm not on the same tooth or ≥2 sites with interproximal PPD ≥5.0 mm not on the same tooth,

(c) mild or no periodontitis: neither severe nor moderate periodontitis.

PPD and CAL were recorded to the nearest full millimetre. Round measurements were calculated to the next higher whole number; for example, a reading of 3.5 mm is recorded as 4.0 mm and a 5.3 mm reading is recorded as 5.0 mm. In cases in which the cement-enamel junction was covered by calculus, hidden by a restoration or loss due to caries or wear lesion, the location of such junction was estimated on the basis of the adjacent teeth.

2.5. Reproducibility. A randomly chosen sample of 580 (20%) individuals was reexamined clinically by the same dentist in order to establish the intraexaminer variance. After consideration of the code numbers of the double examined individuals no differences were recorded between the 1st and the 2nd clinical assessment (Cohen's Kappa =0.94).

2.6. Ethical Consideration. The present study was not an experimental one. In Greece only experimental studies must be reviewed and approved by authorized committees (Dental Schools, Greek Dental Associations, Ministry of Health, etc.).

Subjects who agreed to participate in the present study were informed about the evaluation to which they would be submitted and signed an informed consent form.

2.7. Statistical Analysis. For each individual the values of PPD and CAL at the six sites per tooth were recorded and then classified based on the mentioned criteria in one of the determined periodontal classes.

In the analysis, the variable smoking was coded 0 for nonsmokers or former smokers and 1 for active smokers. Gender was coded 0 for female and 1 for male. Low income and educational level were coded 1 and high levels were coded 0. Similarly, frequent tooth brushing was coded 0. Serum total cholesterol, triglycerides, and C-RP were coded 0 for low levels and 1 for high levels, while HDL-cholesterol was coded 0 for high levels and 1 for low levels. The presence of CHD, hypertension, and diabetes mellitus was coded 1 and the absence 0, as dichotomous variables.

Statistical analysis of questionnaire items was performed by using a multivariate logistic regression analysis model to identify which variables were best associated with CHD. A stepwise selection procedure was used to investigate the influence of possible risk factors on the outcome of CHD. A two-step approach was used for this aim. First, bivariate analysis was used to test the relationship between CHD and the associated factors. Thereby, the criterion for the independent variables to enter the model was set at 0.25. In addition, odds ratios with 95% confidence intervals (CI) were used to assess the bivariate relationships among the examined variables. Then, the mentioned model was used to analyse the factors that were independently related to the presence of CHD. The variables after the bivariate analysis were entered into the model in enter method and then in a backward fashion in order to find out which final variables could be considered as risk factors of CHD. Adjusted odds ratios with 95% CI were assessed as well.

The data analysis was performed using the statistical package of SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA). A P value less than 5% ($P < 0.05$) was considered to be statistically significant.

3. Results

The invitation to participate in the current study was addressed to 3,102 outpatients. Sixty-seven of them were not permanent inhabitants of Athens and excluded from the study sample. Thus, 3,035 outpatients were selected and 63 of them did not meet the mentioned inclusion criteria as they had more than 20 missing teeth or they had received prescription of some of the mentioned drugs for a large period. Also, 60 outpatients refused to participate in the present study. Finally, the study sample consisted of 2,912 outpatients giving a response rate 93.9.%. The mean age of the study sample was 55.6 ± 3.7 years. A total of 448 patients were diagnosed as having CHD, 200 males and 248 females giving an overall prevalence of 15.4%, 14.7% in males and 15.9% in females ($P = 0.051$).

The results showed that gender, educational level, smoking, teeth brushing frequency, diagnosed CHD, serum levels of HDL-cholesterol, triglycerides, and C-RP were significantly associated with clinically classified periodontitis according to the bivariate analysis (Table 1).

Table 1: Descriptive characteristics of the study population according to the bivariate analysis.

Periodontal parameters	No/mild periodontitis		Moderate periodontitis (≥2 interproximal sites PD ≥ 5.0 mm)		Severe periodontitis (≥2 interproximal sites CAL ≥ 4.0 mm and ≥interproximal site PD ≥ 5.0 mm)		P
Variables	N	(%)	N	(%)	N	(%)	
Socioeconomic factors							
Gender							
Males	362	60.3	560	51.3	780	63.9	0.000*
Females	238	39.7	532	48.7	440	36.1	
Income							
Low	318	53.0	521	47.7	596	48.9	0.106
High	282	47.0	571	52.3	624	51.1	
Education							
Low	396	66.0	680	62.3	412	33.7	0.000*
High	204	34.0	412	37.7	808	66.3	
Health habits							
Smoking status							
Smokers	356	59.3	476	43.6	564	46.2	0.000*
Nonsmokers	244	40.7	616	56.4	656	53.8	
Tooth brushing							
≥2 times/day	116	19.3	420	38.5	804	65.9	0.000*
≤2 times/day	484	80.7	672	61.5	416	34.1	
General health							
Diagnosed CHD							
Yes	72	12.0	160	14.7	216	17.7	0.005*
No	528	88.0	932	85.3	1004	82.3	
Diagnosed hypertension							
Yes	276	46.0	524	47.9	596	48.9	0.865
No	324	54.0	568	52.1	624	51.1	
Diagnosed diabetes mellitus							
Yes	416	69.3	636	58.2	716	58.7	0.519
No	184	30.7	456	41.8	504	41.3	
Biomarkers							
Total cholesterol							
Low	259	43.2	475	43.6	557	45.7	0.471
High	341	56.8	617	56.4	663	54.3	
HDL-cholesterol							
High	216	36.0	516	47.3	583	47.8	0.000*
Low	384	64.0	576	52.7	637	52.2	
Triglycerides							
Low	233	38.8	533	48.8	601	49.3	0.000*
High	367	61.2	559	51.2	619	50.7	
C-reactive protein							
Low	431	71.8	657	60.2	741	60.7	0.000*
High	169	28.2	435	39.8	479	39.3	

* P value derived from the chi-square test.

The factors that were associated with the presence of CHD, unadjusted and adjusted OR and 95% CI, are shown in Table 2.

The results after application of the Wald model (backward method) showed that the following variables were significantly associated with the presence of CHD: smoking, presence of hypertension, serum levels of C-reactive protein, and clinically classified periodontitis (Table 3).

The results of the unstratified and stratified multivariate logistic regression analyses are presented in Table 4. They showed that clinically classified periodontitis was positively associated with the presence of CHD after adjustments for several risk factors such as male gender, high income, low educational level, and smoking.

4. Discussion

The current study confirmed that some of the traditional risk factors such as hypertension, high levels of serum C-reactive protein (C-RP), smoking, and clinically classified periodontitis (CCP), which is considered as a nontraditional risk factor, were associated with the presence of CHD. Although many risk factors of CHD have been identified, a significant proportion of this pathological condition cannot be explained by those traditional risk factors [8].

The principle finding of the current study was that a positive relationship between CCP and the presence of CHD was recorded. Similar studies, in which a combination of periodontal disease indices such as probing pocket depth (PPD) and clinical attachment loss (CAL) has used in order to investigate a possible association between periodontitis and CHD, have not been carried out. In previous reports several periodontal indices such as PPD, CAL, dental plaque indices, and alveolar bone level, have been used separately, in order to investigate the possible association between both diseases. Consequently, any attempt of benchmarking with similar studies will be based on the examined indices separately.

The mentioned principle finding of the current study was in line with the results of previous reports. Some authors [16, 22, 23] found that periodontal disease (PD) is a possible causal factor of heart disease, whereas Joshipura et al. [19] reported that the strength of the evidence for this biologically plausible association was found to be insufficient but suggestive of a causal relationship. In another study Pejcic et al. [21] was found a significant relation between indicators of poor periodontal status, such as PPD, CAL, gingival bleeding index, and serum level lipoproteins. These findings suggested that lipoproteins are possible intermediate factors that may link PD to elevated cardiovascular risk.

A case-control study by Latronico et al. [24] supported the existence of an epidemiological association between PD and CHD, in which periodontal parameters such as deep pockets and number of missing teeth seemed to be important risk factors for CVD. Similarly, positive association was recorded in previous reports [8, 10], whereas Johansson et al. [18] found that CHD patients had significantly higher numbers of periodontal pockets 4–6 mm and higher bleeding on probing (BOP).

In a study by Hung et al. [26] was found that periodontal indices such as CAL, PPD, or gingival index (GI) could be indicators for traditional risk factors for CHD, whereas the most plausible explanation for the finding was that periodontal indices are associated with poor oral hygiene, which in turn are associated with oral hygiene related cardiovascular risks as presence of worse periodontal indices, that is, deep pockets, severe CAL.

Meta-analysis of 22 case-control and cross-sectional studies and 12 cohorts studies concluded that the risk for ischemic CVD was significantly higher among individuals with PD [20].

Other investigators [17, 27–29] suggested that there may be some relationship between periodontal inflammation and CHD. Ge et al. [30] reported that moderate and severe chronic periodontitis may be a risk factor of CHD and that fibrinogen could be one of the biological basis which links periodontitis with CHD. In addition, Bahekar et al. [25] in a meta-analysis study confirmed that PD may be a risk factor for CHD.

Because some of these studies were prospective or retrospective, the assessment of PD was often done before the occurrence of cardiovascular events, thus better establishing the temporality of the association.

On the other hand a number of studies have found no relationship between PD and CHD. Little [44] reported that none of the studies from 2005 to 2008 have shown a cause-and-effect relationship between the examined diseases.

A large cross-sectional study of women [45] and a large prospective study of men and women with 12-year followup [46] did not find any statistically significant relationship between PPD or PD and CHD, respectively but found a significant association between tooth loss and increased risk for CVD and CHD mortality.

Similarly, other reports have found either nonsignificant positive trends or no association after adjustment for variables considered to be confounders [43, 47], whereas Bokhari and Khan [48] reported that all studies on the relationship of PD to CVD are inconclusive and most of the data is based on epidemiological studies.

Over the last few years a great deal of studies with different designs such as case-control, retrospective, prospective observational, and meta-analysis has been developed, which have produced contradictory results when estimating the association between both diseases.

The large sample sizes of the mentioned studies provide a good reason for caution with regard to the examined association. However, a major limitation of these studies stems from the self-report nature of PD assessment in which participants were asked by means of a questionnaire whether they had a history of CHD or of other traditional risk factors for CHD such as hypertension or diabetes mellitus or whether they had a history of PD and data collected without an oral clinical examination.

One of the great difficulties in comparing different studies on this subject is the lack of a consistent classification for periodontal disease. Based on published data, it is difficult to reach a conclusion whether there is or not an association between PD and CVD. We made a point of evaluating all

Table 2: Factors associated with the presence of coronary heart disease with unadjusted and adjusted odds ratios and 95% confidence interval.

Parameters	Coronary heart disease, number of patients		OR, 95% CI (unadjusted)		OR, 95% CI (adjusted)	
Variables	Yes	No	OR	95% CI	OR	95% CI
Gender						
Males	200	1352	0.66	0.542–0.812*	1.23	0.756–1.998
Females	248	1112	1.00		1.00	
Income level						
High	216	1024	1.31	1.070–1.602*	1.34	0.725–2.473
Low	232	1440	1.00		1.00	
Educational level						
High	268	1152	1.70	1.382–2.081*	0.71	0.392–1.293
Low	180	1312	1.00		1.00	
Smoking status						
Smokers	352	932	6.03	4.742–7.661*	2.16	1.292–3.594*
Non-smokers	96	1532	1.00		1.00	
Tooth brushing						
≥2 times/day	208	1244	0.85	0.695–1.040	0.80	0.461–1.388
≤2 times/day	240	1220	1.00		1.00	
Diagnosed hypertension						
No	156	1680	0.25	0.202–0.308*	0.40	0.087–0.668*
Yes	292	784	1.00		1.00	
Diagnosed diabetes mellitus						
No	244	1652	0.59	0.479–0.721*	0.99	0.427–2.320
Yes	204	812	1.00		1.00	
Total cholesterol						
Low	140	1712	0.20	0.161–0.248*	0.98	0.526–1.848
High	308	752	1.00		1.00	
HDL-cholesterol						
High	272	1836	0.53	0.428–0.652*	0.75	0.335–1.675
Low	176	628	1.00		1.00	
Triglycerides						
Low	172	1724	0.27	0.217–0.330*	0.56	0.298–1.056
High	276	740	1.00		1.00	
C-reactive protein						
Low	192	1592	0.41	0.335–0.504*	0.62	0.366–1.032
High	256	872	1.00		1.00	
Clinically classified periodontitis						
No/mild	72	528	0.63	0.476–0.844*	0.51	0.319–0.825*
Moderate	160	932	0.80	0.638–0.997	0.66	0.432–0.627*
Severe	216	1004	1.00		1.00	

*$P < 0.01$.

teeth to prevent any bias in data collection. Additionally, our classification sought to aggregate the most important periodontal parameters simultaneously, namely, probing depth, since periodontal pockets are a reservoir for microorganisms with direct access to the connective tissue and circulatory system and CAL, because periodontal recession is the record of past history of PD and its remissions.

Another important factor that may be taken into account during the design process of such studies is the epidemiologic phenomenon that is known as "confounding." Both diseases,

Table 3: Results of the logistic regression analyses performance (wald model).

Variables	*B*	SE	*P*	Exp (*B*)	95% CI for Exp (*B*)
Smoking	0.680	0.232	0.003	1.974	1.252–3.110
Diagnosed hypertension	0.882	0.236	0.000	2.416	1.520–3.840
Serum triglycerides	0.406	0.238	0.088	0.667	0.418–1.062
C-reactive protein	0.556	0.258	0.031	1.743	1.052–2.890
Clinically classified periodontitis	0.581	0.224	0.010	1.787	1.152–2.773
Constant	−3.424	0.315	0.000	0.033	—

Table 4: Results of the unstratified and stratified logistic regression analyses for gender, smoking status, educational level, and income level.

Variables	Clinically classified periodontitis		
Stratified analyses	OR	95% Confidence Interval (CI)	
		Lower	Upper
Gender			
In total cohort	1.229	0.756	1.998
Males	4.142	0.335	7.347
Females	1.689	0.964	2.961
Smoking status			
In total cohort	2.155	1.292	3.594
Smokers	3.004	1.566	5.760
Non-smokers	—	—	—
Educational level			
In total cohort	0.712	0.392	1.293
Low	4.035	2.125	7.664
High	—	—	—
Income level			
In total cohort	1.339	0.725	2.473
Low	—	—	—
High	4.599	2.203	9.602

PD and CHD, share common risk factors, such as smoking and socioeconomic level or status; consequently, a correlation between the mentioned diseases would be expected even if a causal link did not exist. In addition, in case of association, this could be a result of confounding by mutual risk factors. Confounding may also occur through unknown factors, for example, a genetic predisposition. However, the question still remains whether the association between PD and CVD is causal or is confounded by unmeasured factors.

A wide spectrum of studies such as case-control, cross-sectional, and longitudinal studies has recorded that periodontitis is associated with CHD and cerebrovascular disease, even after adjustment for a variety of potential confounders of these associations [55–57], while most of the results reporting a lack of association between PD and CHD are from prospective studies.

In the current study, after controlling for known risk factors such as male gender, low educational level, high income level, and smoking, positively and stronger associations, than those found in the total cohort, were found between CCP and the presence of CHD.

According to Seymour et al. [58] studies to estimate the relationship between periodontal and CH diseases should have a series of characteristics such as the specific choice of the sample, the use of specific periodontal indices, trained and calibrated examiners and a very careful management of co-variables. However, whether an association between PD and CHD could be causal is still uncertain.

The current study has some limitations that should be taken into account before any benchmarking with similar studies. First, the majority of the study population was residents of Athens with different levels of educational and socioeconomic background which in many cases appeared to be low. In Greece, individuals with higher educational and socioeconomic background prefer and receive medical care from private hospitals. Second, in a retrospective study, like the present one, the reliability is not as high as for prospective studies since the interexaminer variability and the presence of systemic bias, regarding sample selection, recall bias and confounders are most likely higher. Furthermore, the results of the study were based on self-reported data regarding the diagnosis of CHD, systemic health conditions, and other epidemiological variables. The response outcomes to the questionnaire items may therefore suffer from inaccuracy. Respondents may underreport, overreport, or choose not to report.

Despite the fact that the personal medical file of the individuals could solve this problem, this factor may lead to limitations regarding the validity when interpreting the results in this study. In addition, in the current study the alveolar bone height or other clinical parameters, such as the number of remaining teeth, were not assessed as indices of measurement of periodontal health. In earlier studies the measurement of PD has ranged from self-reported periodontal disease, partial recording of attachment, the number of teeth left, and the Russell plaque index to 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.

In conclusion, the sample of the present study was not randomly selected from a normal population but as mentioned consisted of outcome patients of a special hospital clinic.

Another limitation is that it is difficult to make a causal statement because of temporal ambiguity related to a retrospective study design, meaning that we did not even know whether gingivitis and periodontitis precede CHD. On the condition that these precede CHD we have to be aware that the time period from exposure to disease is at best short in relation to cardiovascular alterations.

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