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Usefulness of Self-Reported Periodontal Disease to Identify Individuals with Elevated Inflammatory Markers at Risk of Cardiovascular Disease

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Abstract

Periodontal disease has been associated with cardiovascular disease (CVD) and inflammation may represent a common pathophysiology. Oral health screening in the context of CVD risk assessment represents a potential opportunity to identify persons at risk for CVD. The purpose of this study was to determine if self-reported oral health status is independently associated with inflammatory markers and if oral health assessment as part of CVD risk screening can identify at-risk persons without traditional CVD risk factors. A baseline analysis was conducted among participants in the NHLBI Family Intervention Trial for Heart Health (F.I.T. Heart) (n=421; mean age 48±13.5y; 36% non-white) without CVD or diabetes who underwent standardized assessment of oral health, lifestyle, CVD risk factors and inflammatory markers high sensitivity c-reactive protein (hsCRP) and lipoprotein-associated phospholipase A₂ (Lp-PLA₂). Statistical associations between oral health, risk factors and inflammatory markers were assessed and logistic regression was used to adjust for effects of lifestyle and potential confounders. Periodontal disease was independently associated with being in the top Lp-PLA₂ quartile versus the lower three (OR=1.9; 95% CI=1.1–3.2) after adjustment for lifestyle and risk factors. History of periodontal disease was reported by 24% of non-overweight, non-hypertensive, non-hypercholesterolemic participants and among these participants, 37% had elevated hsCRP (≥ 3mg/L) or Lp-PLA₂ (≥ 215ng/mL). In conclusion, self-reported periodontal disease is independently associated with inflammation and common in persons without traditional CVD risk-factors.

Keywords

Oral Health; Cardiovascular Disease; Inflammation; Lipoprotein-Associated Phospholipase A2

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INTRODUCTION

Periodontal disease is highly prevalent, affecting approximately 34% of adults over the age of 30 years (~36 million persons) (1) and has been correlated with the presence of cardiovascular disease (CVD) (2). Whether this association is causal is not yet determined, however research suggests that there may be common underlying pathophysiology. Chronic infection has been linked to vascular inflammation, and both infection and inflammation have been associated with periodontal disease and incident CVD events (2,3). But, not all prior research has controlled for diet and/or lifestyle factors that may be associated with CVD and periodontal disease (3). The purpose of this study was 1) to examine whether self-reported oral health status is independently associated with novel inflammatory markers for CVD risk including high sensitivity c-reactive protein (hsCRP) and lipoprotein-associated phospholipase A₂ (Lp-PLA₂) and 2) to assess whether self-reported oral health status identifies persons with a history of periodontal disease who do not have traditional CVD risk factors in a diverse population of participants eligible for the primary prevention of CVD.

METHODS

This was a cross sectional baseline sub-study of consecutively enrolled participants in the National Heart Lung and Blood Institute (NHLBI) Family Intervention Trial for Heart Health (F.I.T. Heart) (n=421; mean age 48 ± 13.5 years; 36% racial/ethnic minority) designed to test the effectiveness of a screening and educational intervention for family members of patients hospitalized with CVD. Participants were eligible if they were family members or cohabitants of patients hospitalized with CVD, were 20–79 years of age, did not have CVD or diabetes, and spoke either English or Spanish. Demographic information was obtained by standardized questionnaire. All participants signed written informed consent to be a part of the study. The study was approved by the Columbia University Medical Center Internal Review Board.

Oral health status data were collected using the following standardized questions: 1) “Have you ever been informed that you have periodontal (gum) disease?”, 2) “Have you ever received treatment for periodontal disease?”, 3) “Do you have removable partial or complete dentures?”, and 4) “When was the last time you had your teeth cleaned?” Self reported measures of periodontal disease such as these have been shown to be predictive of clinical attachment loss and periodontitis (4,5).

Dietary assessments were completed using the full length Block 98 Food Frequency Questionnaire (6–8). High saturated fat intake was defined as ≥10% of calories from saturated fat per day. High dietary cholesterol intake was defined as ≥ 300 mg/day. Suboptimal fruit and vegetable intake was defined as fewer than 5 combined servings of fruits and vegetables per day. Higher alcohol intake was defined as being at or above the 75th percentile for daily percent of calories from alcohol.

Physical activity level was assessed using standardized questions adapted from the Centers for Disease Control Behavioral Risk Factor Surveillance System Questionnaire (9). Suboptimal exercise level was defined as exercise less than three days per week for 30 minutes per session. Current smoking status was defined by self report as smoker vs. non smoker and confirmed using carbon monoxide breath testing.

Waist circumference and body mass index (BMI) were assessed by trained examiners using NHLBI Clinical Guidelines (10). Above optimal waist circumference was defined as > 102 centimeters [> 40 inches] in men and > 88 centimeters [> 35 inches] in women. Overweight or obese status was defined as BMI ≥ 25.0 kg/M².

Systolic and diastolic blood pressure was assessed by an automated blood pressure monitor in the Columbia University Clinical and Translational Science Award (CTSA) Center using standard protocol (11). Hypertension was defined as a systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg (12).

All participants underwent fasting blood draw at their baseline study visits. Serum and plasma aliquots were prepared from fasting blood samples immediately after blood draw. Determination lipids were performed on blood analyzed (Roche Diagnostics) in the Columbia University CTSA. Low density lipoprotein (LDL) cholesterol was calculated using the Friedewald equation. High sensitivity c-reactive protein (hsCRP) and lipoprotein-associated phospholipase A₂ (Lp-PLA₂), both inflammatory markers that are indicators of CVD risk, were systematically measured in all participants using blood collected at baseline visit. HsCRP was assessed using Kamiya hsCRP kit on serum samples. High hsCRP levels were defined as ≥ 3 mg/L vs. < 3 mg/L. HsCRP values ≥ 10 mg/L were excluded from analysis based on previous work suggesting they reflect acute/non-vascular inflammation (13). Lp-PLA₂ mass was measured using the PLAC test (diaDexus Inc. South San Francisco, CA, USA) on plasma samples. Elevated Lp-PLA₂ levels were defined as being at or above the 75th percentile.

Metabolic syndrome was evaluated using National the Cholesterol Education Program Adult Treatment Panel III definition of the presence of 3 or more of the risk factors 1) abdominal obesity, 2) triglycerides ≥ 150 mg/dL, 3) HDL-cholesterol level < 40 mg/dL (men); < 50 mg/dL(women), 4) blood pressure $\geq 130/85$ mmHg and 5) fasting glucose ≥ 110 mg/dL (14).

All data were collected on standardized forms, double entered into a Microsoft Access database and exported to SAS version 9.1, SAS Institute Inc., Cary, North Carolina, USA for statistical analysis. Continuous and categorical variables were characterized using means and frequency statistics respectively. Spearman coefficients were used to assess the correlation between hsCRP and Lp-PLA₂ and between each of these inflammatory markers and age. Associations between oral health and inflammatory markers, oral health and CVD lifestyle and risk factors, and between CVD lifestyle and risk factors and inflammatory markers were assessed using chi-square statistics. Multiple logistic regression models were used to assess the association between oral health exposure variables and inflammation markers, controlling for age, sex, race/ethnicity, smoking, and potential confounders.

RESULTS

The baseline characteristics of 421 consecutively enrolled F.I.T. Heart study participants in this analysis are listed in Table 1. Mean age was 48.2 ± 13.4 years. The median hsCRP level was 1.05 mg/L (hsCRP ≥ 10.0 mg/L excluded (n=1)). The median Lp-PLA₂ level among all participants was 189.3 ng/mL with 25% of participants having Lp-PLA₂ levels ≥ 215 ng/mL. Age and hsCRP were not correlated ($r=-.01$; $p=.85$), nor were age and Lp-PLA₂ ($r=.05$; $p=.28$) and Lp-PLA₂ and hsCRP were not correlated with each other ($r=.04$; $p=.39$).

Approximately one in four (23%) of participants had a history of diagnosed periodontal disease. Partial or complete removable dentures were utilized by 10% of participants (n=44) and of them 38% reported a history of diagnosed periodontal disease. A duration of greater than 12 months since their last dental cleaning was reported by 23% of participants (n=97). Among those with greater than 12 months since last cleaning, 19% reported diagnosed periodontal disease.

Participants with a history of diagnosed periodontal disease were almost two times more likely to have Lp-PLA₂ levels in the highest quartile versus the lower three (OR=1.8; 95% CI=1.1–3.0) than those who did not have a history of diagnosed periodontal disease. Those reporting no dental cleaning in greater than a year were more likely to have hsCRP ≥ 3 mg/L vs. < 3 mg/L.

L (OR=1.7; 95% CI=1.0–2.9) compared to those who reported a cleaning within the past year. Neither a history of treatment for periodontal disease, or having partial or complete removable dentures was significantly associated with elevated levels of hsCRP or Lp-PLA₂ (Table 2).

Males were less likely than females to have elevated hsCRP (≥ 3 mg/L vs. < 3 mg/L) and more likely than females to have Lp-PLA₂ in the highest quartile. Non-white participants were more likely to have elevated hsCRP compared to whites and less likely to have Lp-PLA₂ in the highest quartile. Age, education level and having health insurance were not associated with hsCRP or Lp-PLA₂ (Table 2).

In univariate assessment of the association between CVD lifestyle and traditional CVD risk factors, high waist circumference was positively associated with hsCRP levels as was overweight or obese status. Neither was significantly associated with Lp-PLA₂ levels. Saturated fat intake was significantly associated with higher Lp-PLA₂ and not with hsCRP. Likewise, higher LDL cholesterol levels were significantly associated with higher Lp-PLA₂ levels. Dietary cholesterol, alcohol, fruit and vegetable intake, exercise level, smoking and blood pressure were not significantly associated with increased inflammatory marker levels in this study (Table 2).

The observed association between self-reported periodontal disease and increased Lp-PLA₂ levels remained statistically significant when controlling for age, sex, race, smoking, LDL-cholesterol and dietary saturated fat in a multiple logistic model (OR=1.9; 95% CI=1.1–3.2). The association between last dental cleaning > 12 months ago and hsCRP level did not retain statistical significance after adjustment for age, sex, race, smoking, waist circumference and BMI.

We examined the prevalence of self-reported history of periodontal disease among participants without traditional cardiovascular risk factors and found that diagnosed periodontal disease was present 23–29% of the time in the absence of individual and multiple CVD lifestyle and risk factors traditionally measured during CVD risk assessment (Table 3). Over one in five (24%) of non-hypertensive participants without elevated LDL-cholesterol or overweight/obesity reported a history of periodontal disease diagnosis. Among those with periodontal disease and without these three traditional CVD risk factors 37% had elevated hsCRP or Lp-PLA₂.

DISCUSSION

In a diverse population of individuals eligible for the primary prevention of CVD, a history of periodontal disease was associated with significantly higher levels of Lp-PLA₂ compared with those without periodontal disease. When adjusted for potential confounders and lifestyle factors, this association remained statistically significant. To our knowledge this is the first report of an association between oral health and Lp-PLA₂. These data support a possible independent association between oral health and inflammation, suggesting that inflammation may be a factor in the relationship between oral health and CVD. We also showed that diagnosed periodontal disease is present in patients without traditional CVD risk factors and that many of these individuals have increased inflammatory markers (hsCRP or Lp-PLA₂).

In contrast to some studies, we did not find an association between oral health and hsCRP after adjustment. This may be related to our primary prevention population with lower mean hsCRP levels compared to means reported in patients with established CVD (15–17) where both hsCRP and Lp-PLA₂ have been independently correlated with CVD risk (18,19). Alternatively, because we controlled for BMI, smoking and other lifestyle factors, our results may discordant due to control for confounding.

We did not show a correlation of hsCRP and Lp-PLA₂ with each other, which may reflect disparate inflammatory pathways (20) and correlation with varying CVD risk factors. For example, central adiposity and obesity were strongly associated with increased hsCRP levels in our study, and in others (19), but were not found to be associated with higher levels of Lp-PLA₂. This is consistent with past research in both men and women which also failed to correlate Lp-PLA₂ levels with body mass index (21–23) and supports specificity of Lp-PLA₂ to vascular rather than systemic inflammatory processes (24). Higher levels of Lp-PLA₂ have been identified on inflamed, rupture prone plaques, and the active Lp-PLA₂ product lysophosphatidylcholine has been correlated with human endothelial dysfunction in persons with early stages of atherosclerosis (24,25).

Periodontal disease diagnosis was reported by 23% of our screening population which is lower than nationally estimated prevalence among adults aged ≥ 30 years (1). This could be attributed to 10% of study participants being under the age of 30 years with only 4 participants in this age range reporting a diagnosis of periodontal disease.

Strengths of this study include our population with well characterized CVD risk, lifestyle, and other risk factors allowing us to examine interrelation among these, oral health, and inflammation. Participants were ethnically diverse, eligible for the primary prevention of CVD, and actively seeking CVD risk screening suggesting these findings may be generalizable and applicable to other primary prevention populations.

A limitation of this study is that we used self-reported data instead of clinical examination to assess oral health status. Nonetheless past research has shown good correlation between self report and clinical evaluation (26) and non-differential misclassification of disease status would generally bias towards the null making a spurious association unlikely. We are limited in drawing conclusions about directionality of relations between oral health and inflammatory markers due to the cross sectional design; specifically it is not possible to conclude from these data that oral health is a risk marker for CVD or CVD outcomes, or that any therapy based on oral health status will be effective. Our data suggest that “at risk” persons who may otherwise not be identified by traditional CVD risk screening might be identified through oral health screening. Further research prospectively examining the relationship between oral health status, CVD biomarkers and incident CVD is needed to determine if there is a causal link between oral health and CVD.

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Table 1

Characteristics of Cardiovascular Disease Risk Screening Participants (n=421)

	n (%)
Male	147 (35%)
Age \geq 65 years	49 (12%)
Non-white race	151 (36%)
\leq High school education	92 (22%)
No health insurance	62 (15%)
Low density lipoprotein cholesterol \geq 3.37 mmol/L [\geq 130 mg/dL]	159 (38%)
Blood pressure \geq 140/90 mmHg	99 (24%)
Waist circumference > 102 cm (M); > 88 cm (F)	161 (38%)
Body mass index \geq 25 kg/M ²	274 (66%)
Metabolic syndrome	75 (18%)
Saturated fat \geq 10% of calories/day	240 (57%)
Dietary cholesterol \geq 300mg/day	107 (26%)
Fruit + vegetables < 5 servings/day	254 (60%)
Dietary alcohol \geq 75 th percentile (\geq 5.2% kcal/day)	108 (25%)
Exercise < 3 days per week for 30 minutes	290 (69%)
Current smoker	41 (10%)
Framingham risk \geq 10%	35 (8%)
Ever diagnosed with periodontal disease	95 (24%)
Ever treated for periodontal disease	82 (20%)
Wears partial/complete removable dentures	44 (10%)
Last dental cleaning >12 months ago	97 (23%)

Table 2

Associations between Oral Health, Demographic or Lifestyle Factors and Inflammatory Markers

Variable	hsCRP	Lp-PLA ₂
	(≥3mg/L vs. <3mg/L) OR (95% CI)	(≥215ng/mL vs. <215ng/mL) OR (95% CI)
Ever diagnosed with periodontal disease	1.2 (.68–2.0)	1.8 (1.1–3.0)
Ever treated for periodontal disease	1.2 (.65–2.1)	1.5 (.89–2.6)
Wears removable dentures	.98 (.45–2.1)	1.1 (.54–2.2)
Last dental cleaning >12 months ago	1.7 (1.0–2.9)	1.5 (.88–2.4)
Male	.58 (.34–.98)	1.6 (1.0–2.5)
≥ 65 years old	1.2 (.60–2.4)	1.1 (.56–2.2)
Non-white	2.2 (1.4–3.5)	.36 (.21–.61)
≤ High school education	1.2 (.70–2.2)	1.0 (.60–1.7)
No health insurance	1.4 (.73–2.6)	1.4 (.77–2.5)
Low density lipoprotein cholesterol ≥3.37 mmol/L [≥ 130 mg/dL]	.87 (.53–1.4)	2.0 (1.3–3.2)
Blood pressure ≥ 140/90 mmHg	1.2 (.69–2.1)	1.3 (.76–2.1)
Waist circumference > 102cm (Male); > 88cm (Female)	3.7 (2.2–6.0)	1.2 (.74–1.8)
Body mass index ≥ 25 kg/M ²	3.1 (1.7–5.5)	1.4 (.87–2.3)
Metabolic syndrome	2.1 (1.2–3.7)	1.1 (.64–2.0)
Saturated fat ≥ 10% of calories/day	1.3 (.82–2.2)	2.0 (1.2–3.2)
Dietary cholesterol ≥ 300 mg/day	1.1 (.62–1.8)	1.3 (.82–2.2)
Fruit + vegetables < 5 servings/day	1.4 (.88–2.4)	.72 (.46–1.1)
Dietary alcohol ≥ 75 th percentile	.66 (.37–1.2)	1.1 (.66–1.8)
Exercise < 3 days per week 30 minutes	1.2 (.74–2.1)	.80 (.50–1.3)
Current smoker	.60 (.24–1.5)	.84 (.39–1.8)
Framingham risk ≥ 10%	.62 (.23–1.6)	1.1 (.48–2.3)

Table 3

Prevalence of Periodontal Disease and Inflammatory Markers by Risk Factor Status

Variable	At Risk Factor Goal	Percent At Risk Factor Goal with Periodontal Disease	Percent At Risk Factor Goal with Periodontal Disease and Elevated Lp-PLA ₂ or hsCRP
Low density lipoprotein cholesterol < 3.37 mmol/L [< 130 mg/dL]	259 (62%)	24%	11%
Blood pressure < 140/90 mmHg	322 (76%)	24%	11%
Waist circumference ≤ 102 cm (M); ≤ 88 cm (F)	260 (62%)	23%	9%
Body mass index < 25 kg/M ²	144 (34%)	24%	10%
Saturated fat < 10% of calories/day	179 (43%)	28%	11%
Dietary cholesterol < 300mg/day	312 (74%)	24%	13%
Fruit and vegetable intake ≥ 5 servings/day	167 (40%)	29%	15%
Exercise ≥ 3 days/week for 30 minutes	130 (31%)	23%	13%
Non- Smoker	378 (90%)	24%	12%
Low density lipoprotein cholesterol < 3.37 mmol/L [< 130 mg/dL] and blood pressure <140/90mmHg and body mass index <25 kg/M ²	87 (21%)	24%	9%