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The association between periodontitis and arterial stiffening among the hypertensive middle-aged and elderly U.S. Population

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Arterial stiffening is an independent predictor of cardiovascular diseases, closely associated with hypertension and aging. Periodontitis, a chronic inflammatory disease caused by microbial imbalances, has been linked to systemic inflammation and endothelial dysfunction. This study aims to investigate the association between periodontitis and arterial stiffening in hypertensive individuals. Data utilized in this study were sourced from the 2009–2014 National Health and Nutrition Examination Survey (NHANES). A total of 3165 hypertensive patients aged ≥ 50 years were enrolled. The relationship between the severity of periodontitis and arterial stiffening (PP ≥ 60) was analyzed using multivariate logistic regression model. Moreover, the associations between pocket depth (PD) and clinical attachment loss (CAL) with arterial stiffening were investigated using multivariate logistic regression model and restricted cubic splines. Among the patients, 1223 (39%) exhibited no or mild periodontal disease, while 1447 (46%) and 495 (15%) were diagnosed with moderate and severe periodontal disease, respectively. Moderate and severe periodontitis were associated with higher odds of arterial stiffening compared to no/mild periodontitis in the fully adjusted model (moderate: OR 1.30 [95% CI 1.09–1.55], *P* = 0.004; severe: OR 1.35 [95% CI 1.05–1.73], *P* = 0.019; *P* for trend < 0.001). Higher quartiles of PD and CAL scores were significantly associated with greater odds of arterial stiffening (PD Q4 vs. Q1: OR 1.41 [95% CI 1.12–1.79], *P* = 0.004; CAL Q4 vs. Q1: 1.31 [95% CI 1.03–1.67], *P* = 0.030), with evidence of linear dose-response relationships ($P_{\text{non-linear association}}$=0.114 for PD; $P_{\text{non-linear association}}$=0.308 for CAL). Subgroup analyses showed that the association between periodontitis severity and arterial stiffening remained significant in participants without diabetes or chronic kidney disease. In hypertensive patients aged 50 years and over, periodontitis is associated with elevated PP, thus reinforcing the association between periodontitis and arterial stiffening. Screening and treating periodontitis may offer additional clinical benefits.

Keywords Periodontitis, Arterial stiffening, Pulse pressure, Older adults, NHANES

Odontogenic infection is a major source of the global disease burden. According to the National Health and Nutrition Examination Survey (NHANES), the prevalence of severe and non-severe periodontitis in adults aged 30–44 was 4% and 25%, respectively, while in adults aged ≥ 65 it was 9% and 51%[1].Periodontitis is a chronic multi-factorial inflammatory disease caused by the imbalance of local microbial ecology[2]. Numerous studies have shown that periodontitis can lead to systemic inflammatory response, immune metabolism changes, and vascular endothelial dysfunction. Effective treatment can reduce the average PPD and the number of periodontal pathogens in patients with periodontitis, and reduce the level of cardiovascular risk mediators[3,4]. There is increasing evidence linking periodontitis with heart failure, coronary heart disease, atrial fibrillation, and other cardiovascular diseases[5–8].

Arterial stiffening is the hardening of blood vessel walls. It caused by elastin fiber and collagen disorder, oxidative stress, mineral metabolism disorder, and low-grade inflammation, and is closely associated with hypertension and aging[9]. Arterial stiffening is an early marker of structure and functional changes in the vessel walls and an independent predictor of cardiovascular diseases[10,11]. Arterial stiffening can be measured by a variety of non-invasive techniques. Pulse pressure (PP) is a marker of arterial stiffening that can predict adverse cardiovascular events and effectively indicate arterial stiffening in the elderly[12].

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Chronic low-grade systemic inflammation caused and maintained by periodontitis may be associated with an increased risk of hypertension and ASCVD in patients with severe periodontitis[13,14]. Studies have shown that the degree of arterial stiffening is significantly correlated with white blood cell count, neutrophil/lymphocyte ratio, C-reactive protein, adhesion molecules, fibrinogen and other inflammatory markers[15]. Periodontitis can induce a systemic inflammatory response, endothelial dysfunction, and other pathological changes associated with arterial stiffening, thus prompting further investigation into the relationship between periodontitis and arterial stiffening. At present, the research results on the association between periodontitis and arterial stiffening are inconsistent, and the sample size of existing studies is relatively small, so the evidence supporting the research results is insufficient[16]. This study used the NHANES data from 2009 to 2014 to observe the association between periodontitis and arterial stiffening in hypertensive patients, which may further guide the improvement of arterial stiffening by periodontitis treatment.

Methods

Study design and participants

This study utilized data obtained from the NHANES 2009–2014 cycles. The NHANES is a cross-sectional survey aimed at assessing the nutritional and health status of the U.S. population. Among the initial sample of 5,589 participants aged 50 years or older with hypertension, we excluded individuals who had not undergone a comprehensive oral health examination ($n = 2,077$) and those without recorded blood pressure measurements or SBP < 60/DBP < 30 ($n = 420$), resulting in a sample of 3,389 participants. After further excluding individuals with incomplete covariates data ($n = 224$), our study ultimately included 3,165 participants (Fig. 1). The data collection protocol was approved by Ethics Review Board of the National Center for Health Statistics, and all participants signed informed consent. All methods were performed in accordance with the relevant guidelines and regulations.

Blood pressure measurement

The measurement of arterial blood pressure (BP) was conducted by trained physicians at mobile examination centers (MECs). After the participants rested for about 5 min, consecutive measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) are taken three times, with SBP and DBP calculated as the mean of the three readings. PP, defined as the difference between SBP and DBP, was calculated, and a PP value ≥ 60 mm Hg indicated arterial stiffening as described in previous studies[17–20].

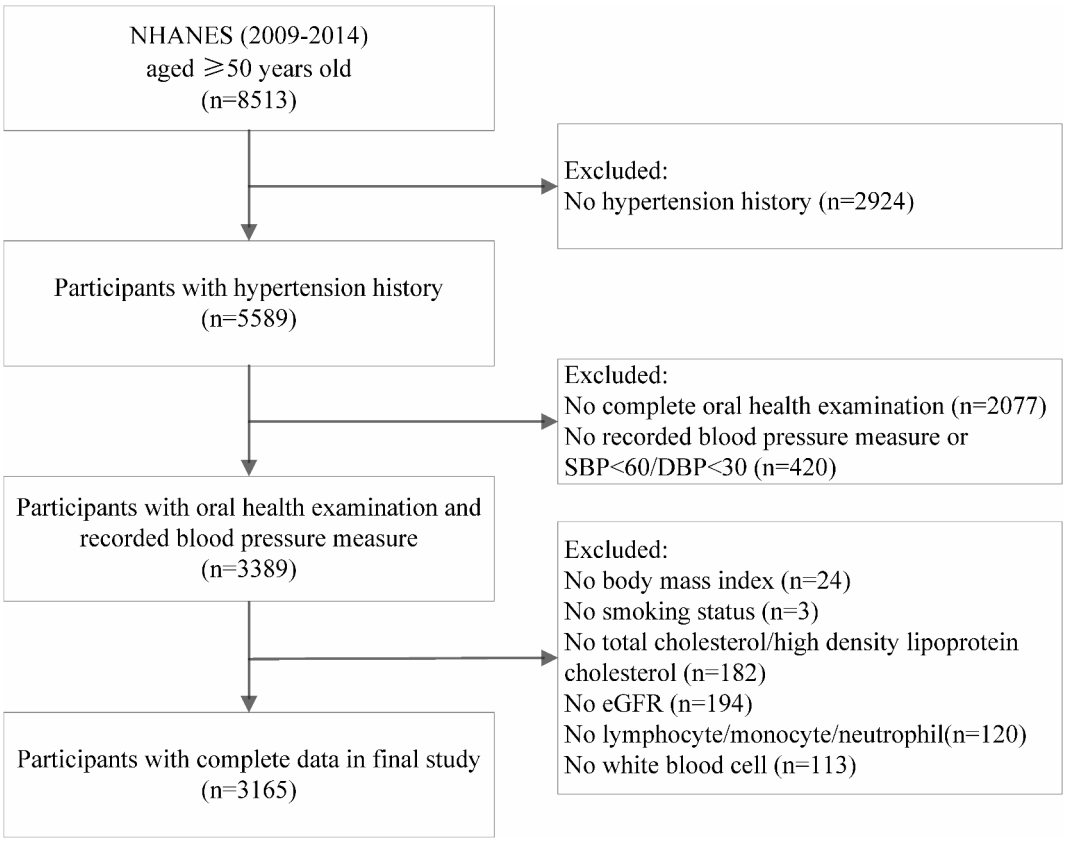

Fig. 1. Participants selection flow chart.

Periodontal examination

The periodontal examination comprised a comprehensive assessment of pocket depth (PD) and clinical attachment loss (CAL) for each tooth at six sites. The severity of periodontal disease was classified based on the periodontal monitoring scheme recommended by American Academy of Periodontology. Participants with at least 2 interproximal CAL ≥ 3 mm, and at least 2 interproximal PD ≥ 4 mm (not on the same tooth) or 1 PD ≥ 5 mm were classified as having mild periodontitis. Participants with at least 2 interproximal CAL ≥ 4 mm (not on the same tooth) or at least 2 interproximal PD ≥ 5 mm (not on the same tooth) were classified as having moderate periodontitis. Participants with at least 2 interproximal CAL ≥ 6 mm (not on the same tooth) and at least 1 interproximal PD ≥ 5 mm were classified as having severe periodontitis. Participants not meeting the above criteria were classified as having no periodontitis.

Covariates

The following covariates were considered: age, sex, ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, and other race), education (less than 11th grade, high-school grade and above), marital status (married/with a partner, and widowed/divorced/other), smoking, body mass index (BMI), total cholesterol to high density lipoprotein cholesterol ratio, diabetes, estimated glomerular filtration rate (eGFR), mean arterial pressure (MAP), white blood cell count, monocyte count, neutrophil count, lymphocyte count, and C-reactive protein (CRP). The eGFR was calculated using the Chronic Kidney Disease Epidemiology equation. MAP was defined as the sum of DBP and one-third of pulse pressure.

Statistical analysis

All statistical analyses were conducted using R version 4.0.3. In the descriptive analysis, continuous variables were presented as means with standard deviations (SD), and categorical variables were presented as count with percentages. Baseline characteristics stratified by periodontitis severity were compared using analysis of variance for continuous variables and chi-square test for categorical variables.

Multivariate logistic regression models adjusted for confounders was used to examine the association between periodontitis severity and arterial stiffening (PP ≥ 60). For all multivariate analysis in this study, 5 models were constructed: following the initial model 1 adjusted for age, sex, and ethnicity, 4 progressively adjusted models were performed (model 2: further including marital status and education; model 3: also including smoking, body mass index, total cholesterol/high density lipoprotein cholesterol, eGFR, and diabetes; model 4: additionally adjustment for mean arterial pressure; model 5: further adjusting for white blood cell count, monocyte count, neutrophil count, and lymphocyte count). Furthermore, the associations between PD/CAL and arterial stiffening were examined using multivariate logistic regression models. We employed restricted cubic splines (using 3 knots at the 10th, 50th, and 90th percentiles of the distribution) to estimate the relationship between PD/CAL and arterial stiffening. Additionally, the association between periodontitis severity and arterial stiffening was evaluated in subgroups stratified by diabetes or chronic kidney disease. A two-sided p-value < 0.05 was considered statistically significant.

Results

During the NHANES survey from 2009 to 2014, a total of 3165 participants aged 50 and above with coexisting hypertension underwent periodontal examination (Fig. 1). Among them, 1223 cases (39%) had no periodontitis or mild periodontitis, while 1447 cases (46%) had moderate periodontitis, and 495 cases (15%) had severe periodontitis. Baseline characteristics of participants recruited based on the severity of periodontitis were shown in Table 1. Overall, individuals with moderate or severe periodontitis tended to be male, Non-Hispanic Black or Other races, unmarried, with lower educational attainment, lower BMI, and a higher diagnosis rate of diabetes. Mean SBP, DBP, MAP, PP, total cholesterol/high density lipoprotein cholesterol, eGFR, white blood cell, monocyte, and neutrophil gradually increased with changes in severity of periodontitis.

Moderate and severe periodontitis were associated with higher odds of arterial stiffening compared to no/mild periodontitis in Model 1 (moderate: OR 1.39 [95% CI 1.17–1.65], $P < 0.001$; severe: OR 1.58 [95% CI 1.25-2.00], $P < 0.001$; P for trend < 0.001) (Table 2). The similar associations were also found in full adjusted model 5 (P for trend < 0.001), with a full adjusted OR of 1.30 (95% CI, 1.09–1.55, $P = 0.004$) for moderate periodontitis, and of 1.35 (95% CI, 1.05–1.73, $P = 0.019$) for severe periodontitis (Table 2).

Participants in the study were categorized into four groups based on the quartiles of PD (< 1.80, 1.80–2.19, 2.19–2.80, ≥ 2.80 mm) and CAL (< 1.90, 1.90–2.53, 2.53–3.67, ≥ 3.67 mm). The higher quartile of PD scores was associated with the significant greater odds for arterial stiffening compared to the lowest quartile (Q1) in full adjusted Model 5 (Q3 vs. Q1: OR, 1.33, 95% CI, 1.06–1.67, $P = 0.013$; Q4 vs. Q1: OR, 1.41, 95% CI, 1.12–1.79, $P = 0.004$; P for trend = 0.001) (Table 3). The same analyses for CAL scores showed similar association with arterial stiffening in full adjusted Model 5 (Q4 vs. Q1: OR, 1.31, 95% CI, 1.03–1.67, $P = 0.030$; P for trend = 0.035) (Table 3). There appeared to be a linear dose-response relationship between PD ($P_{\text{overall association}} = 0.003$; $P_{\text{non-linear association}} = 0.114$) and CAL ($P_{\text{overall association}} = 0.030$; $P_{\text{non-linear association}} = 0.308$) scores with arterial stiffening (Fig. 2).

When stratified by diabetes, in the subgroup without diabetes, moderate (OR 1.29, 95% CI 1.04–1.60, $P = 0.020$) and severe periodontitis (OR 1.40, 95% CI 1.04–1.90, $P = 0.029$) had significant higher OR for arterial stiffening compared with no/mild periodontitis, whereas no statistical relationship was found among participants with diabetes (Table 4). When stratified by chronic kidney disease, in the subgroup without chronic kidney disease, moderate (OR, 1.40, 95% CI, 1.04–1.90, $P = 0.004$) and severe periodontitis (OR, 1.48, 95% CI, 1.14–1.93, $P = 0.004$) had significant higher OR for arterial stiffening compared with no/mild periodontitis, whereas no statistical association was found in the subgroup of chronic kidney disease (Table 4).

Characteristics	Total	No/Mild Periodontitis	Moderate Periodontitis	Severe Periodontitis	*P* value
Number	3165	1223	1447	495	
Age, years	65.0 ± 9.1	64.1 ± 9.1	66.3 ± 9.2	63.2 ± 8.5	< 0.001
Sex, n (%)					< 0.001
male	1560 (49.3)	461 (29.6)	761 (48.8)	338 (21.7)	
female	1605 (50.7)	762 (47.5)	686 (42.7)	157 (9.8)	
Ethnicity, n (%)					< 0.001
Non-Hispanic White	1397 (44.1)	655 (46.9)	599 (42.9)	143 (10.2)	
Non-Hispanic Black	803 (25.4)	247 (30.8)	390 (48.6)	166 (20.7)	
Mexican American/Hispanic	295 (9.3)	107 (36.3)	146 (49.5)	42 (14.2)	
Other	670 (21.2)	214 (31.9)	312 (46.6)	144 (21.5)	
Education, n (%)					< 0.001
below high school	847 (26.8)	214 (25.3)	433 (51.1)	200 (23.6)	
high school and above	2318 (73.2)	1009 (43.5)	1014 (43.7)	295 (12.7)	
Marital status, n(%)					0.01
other	1378 (43.5)	496 (36)	644 (46.7)	238 (17.3)	
married	1787 (56.5)	727 (40.7)	803 (44.9)	257 (14.4)	
Smoking, n (%)					< 0.001
no	1677 (53.0)	750 (44.7)	728 (43.4)	199 (11.9)	
yes	1488 (47.0)	473 (31.8)	719 (48.3)	296 (19.9)	
Body mass index, kg/m^2	30.1 ± 6.6	30.5 ± 6.4	30.0 ± 6.9	29.5 ± 6.3	0.011
Systolic blood pressure, mmHg	137.5 ± 20.0	134.9 ± 19.1	138.6 ± 19.9	140.6 ± 21.9	< 0.001
Diastolic blood pressure, mmHg	72.6 ± 13.1	72.9 ± 12.5	71.7 ± 13.3	74.4 ± 13.4	< 0.001
Mean arterial pressure, mmHg	94.2 ± 12.6	93.6 ± 11.8	94.0 ± 12.7	96.5 ± 13.7	< 0.001
Pulse pressure	64.9 ± 20.1	61.9 ± 19.6	67.0 ± 20.1	66.2 ± 20.4	< 0.001
Pulse pressure ≥ 60, n(%)					< 0.001
no	1312 (41.5)	586 (44.7)	531 (40.5)	195 (14.9)	
yes	1853 (58.5)	637 (34.4)	916 (49.4)	300 (16.2)	
Total cholesterol /High density lipoprotein cholesterol	3.9 ± 1.3	3.9 ± 1.3	3.9 ± 1.3	4.1 ± 1.4	0.026
Diabetes diagnosis, n(%)					< 0.001
no	2195 (69.4)	913 (41.6)	940 (42.8)	342 (15.6)	
yes	970 (30.6)	310 (32)	507 (52.3)	153 (15.8)	
eGFR, mL/(min·1.73m^2)	79.3 ± 21.4	78.4 ± 19.5	78.0 ± 22.6	85.1 ± 21.5	< 0.001
White blood cell	7.0 ± 2.6	6.8 ± 1.9	7.0 ± 2.0	7.6 ± 4.7	< 0.001
Lymphocyte	2.0 ± 0.7	2.0 ± 0.7	2.0 ± 0.8	2.1 ± 0.7	0.147
Monocyte	0.6 ± 0.2	0.5 ± 0.2	0.6 ± 0.2	0.6 ± 0.3	< 0.001
Neutrophil	4.2 ± 2.1	4.0 ± 1.5	4.2 ± 1.6	4.6 ± 4.0	< 0.001
CRP[§]	0.5 ± 0.7	0.4 ± 0.6	0.4 ± 0.7	0.5 ± 1.1	0.379

Table 1. Demographic characteristics of middle and aged adults (≥ 50 y) by periodontal disease severity: National health and nutrition examination survey 2009 to 2014. [§] CRP only measured in NHANES 2009–2010 cycle ($n = 1120$).

Discussion

Arterial stiffening tends to increase significantly with age, particularly after the age of 50[21]. Additionally, pulse pressure is more likely to indicate the level of arterial stiffening in individuals over 50 years old[12,22]. Some clinical studies have shown that PP ≥ 60mmHg has good clinical predictive value for cardiovascular adverse events, so it is considered as a clinical indicator of arterial stiffening[23–25]. Blood pressure is an important risk factor for arterial stiffening[26], and a series of inflammatory biomarkers have been shown to be associated with increased arterial stiffening and refractory hypertension[27]. The association between hypertension and periodontitis has been confirmed by many studies[28,29]. In this study focusing on hypertensive patients aged ≥ 50 years, even after adjusting for the potential impact of hypertension on arterial stiffening by including mean arterial pressure as a covariate, the results still show an independent association between the severity of periodontitis and arterial stiffening. Higher PD and CAL scores were associated with arterial stiffening, with the restricted cubic spline results indicating no evidence of a nonlinear relationship between them. Subgroup analyses showed that the association between periodontitis severity and arterial stiffening remained significant in participants without diabetes or chronic kidney disease.

This study found significant differences in the levels of inflammatory cells among groups with varying degrees of periodontitis. Porphyromonas gingivalis (Pg) is considered a key pathogen promoting the development of severe periodontitis and can produces a variety of virulence factors[30]. Pg has been detected in vascular tissues

Models	No/Mild Periodontitis	Moderate Periodontitis	Severe Periodontitis	
	OR(95% CI)	OR(95% CI)	OR(95% CI)	*P* for trend
Model 1	Ref	1.39(1.17–1.65)***	1.58(1.25-2.00)***	< 0.001
Model 2	Ref	1.35(1.14–1.61)***	1.50(1.18–1.90)**	< 0.001
Model 3	Ref	1.33(1.12–1.58)**	1.44(1.14–1.84)**	0.001
Model 4	Ref	1.31(1.09–1.56)**	1.37(1.07–1.76)*	0.003
Model 5	Ref	1.30(1.09–1.55)**	1.35(1.05–1.73)*	0.005

Table 2. Multivariate logistic regression models for association between periodontitis severity and arterial stiffening (Pulse pressure ≥ 60). Model 1, model covariates were age, sex, and ethnicity. Model 2, model covariates were model 1 plus marital status, education. Model 3, model covariates were model 2 plus smoking, body mass index, total cholesterol/high density lipoprotein cholesterol, eGFR, and diabetes. Model 4, model covariates were model 3 plus mean arterial pressure. Model 5, model covariates were model 4 plus white blood cell, monocyte, neutrophil, and lymphocyte. OR(95% CI), odds ratio and 95% confidence interval. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

Periodontal Score	Models	OR(95% CI)				*P* for trend
	Quantile	Q1(< 1.80)	Q2(1.80–2.19)	Q3(2.19–2.80)	Q4(≥ 2.80)	
PD	Num	782	798	787	798	
	Model 1	Ref	1.08(0.87–1.34)	1.36(1.09–1.69)**	1.60(1.28-2.00)***	< 0.001
	Model 2	Ref	1.08(0.87–1.34)	1.33(1.07–1.66)*	1.52(1.21–1.90)***	< 0.001
	Model 3	Ref	1.08(0.87–1.33)	1.30(1.05–1.63)*	1.48(1.18–1.86)**	< 0.001
	Model 4	Ref	1.11(0.89–1.38)	1.34(1.07–1.68)*	1.44(1.14–1.83)**	0.001
	Model 5	Ref	1.10(0.88–1.37)	1.33(1.06–1.67)*	1.41(1.12–1.79)**	0.001
CAL	Quantile	Q1(< 1.90)	Q2(1.90–2.53)	Q3(2.53–3.67)	Q4(≥ 3.67)	
	Num	787	795	779	804	
	Model 1	Ref	1.20(0.97–1.49)	1.30(1.04–1.62)*	1.53(1.23–1.92)***	< 0.001
	Model 2	Ref	1.19(0.96–1.48)	1.25(1.00-1.56)*	1.43(1.14–1.81)**	0.003
	Model 3	Ref	1.18(0.95–1.46)	1.23(0.98–1.53)	1.39(1.09–1.76)**	0.008
	Model 4	Ref	1.15(0.92–1.43)	1.18(0.94–1.49)	1.32(1.04–1.69)*	0.028
	Model 5	Ref	1.14(0.91–1.42)	1.17(0.93–1.47)	1.31(1.03–1.67)*	0.035

Table 3. Multivariate logistic regression models for association between PD/CAL and arterial stiffening (Pulse pressure ≥ 60). Model 1, model covariates were age, sex, and ethnicity. Model 2, model covariates were model 1 plus marital status, education. Model 3, model covariates were model 2 plus smoking, body mass index, total cholesterol/high density lipoprotein cholesterol, eGFR, and diabetes. Model 4, model covariates were model 3 plus mean arterial pressure. Model 5, model covariates were model 4 plus white blood cell, monocyte, neutrophil, and lymphocyte. OR(95% CI), odds ratio and 95% confidence interval; PD, probing depth; CAL, clinical attachment loss. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

and heart valves[31,32]. The gingival protease produced by Pg can impact the vascular permeability of endothelial cells, leading to edema, chronic inflammation, and vascular injury[33]. These evidences suggest that periodontitis may be an important factor in the development of CVD. Additionally, a cross-sectional study of 127 patients with ischemic heart disease showed that patients with high Pg-IgG levels had statistically higher pulse pressure than those with low PG-IgG levels, supporting the potential involvement of Pg in arterial stiffening among patients with periodontitis[34]. In addition, a range of inflammatory biomarkers have been shown to be associated with increased arterial stiffening. In this study, the severity of periodontitis was independently associated with arterial stiffness in hypertensive patients, even after adjustment for leukocytes, monocytes, and neutrophils. Although inflammatory markers such as IL-1, IL-6, TNF, and high-sensitivity CRP were lacking in this study, previous studies have shown that interleukin-6, tumor necrosis factor, and high-sensitivity C-reactive protein are associated with hypertension[35,36]. Periodontal treatment can reduce the level of CRP[3] and reduce the levels of inflammatory factors and arterial stiffening in patients with refractory hypertension[37,38]. Therefore, inflammatory response may be a potential mechanism for the association between periodontitis and arterial stiffening.

Studies on the association between periodontitis and arterial stiffening are not completely uniform. A cross-sectional study of 269 patients with periodontitis revealed a positive linear association between pulse wave velocity (PWV) and the severity of periodontal disease[39]. In another cross-sectional study involving 158 dental patients, PWV was significantly higher in patients with severe periodontitis compared with healthy periodontal controls[40]. However, a cross-sectional study of 291 healthy Japanese men showed that the association between PWV and periodontal disease disappeared after adjusting for systolic blood pressure, age, and smoking[41]. Nonetheless, this study, which included a large sample of hypertensive individuals, still demonstrated an

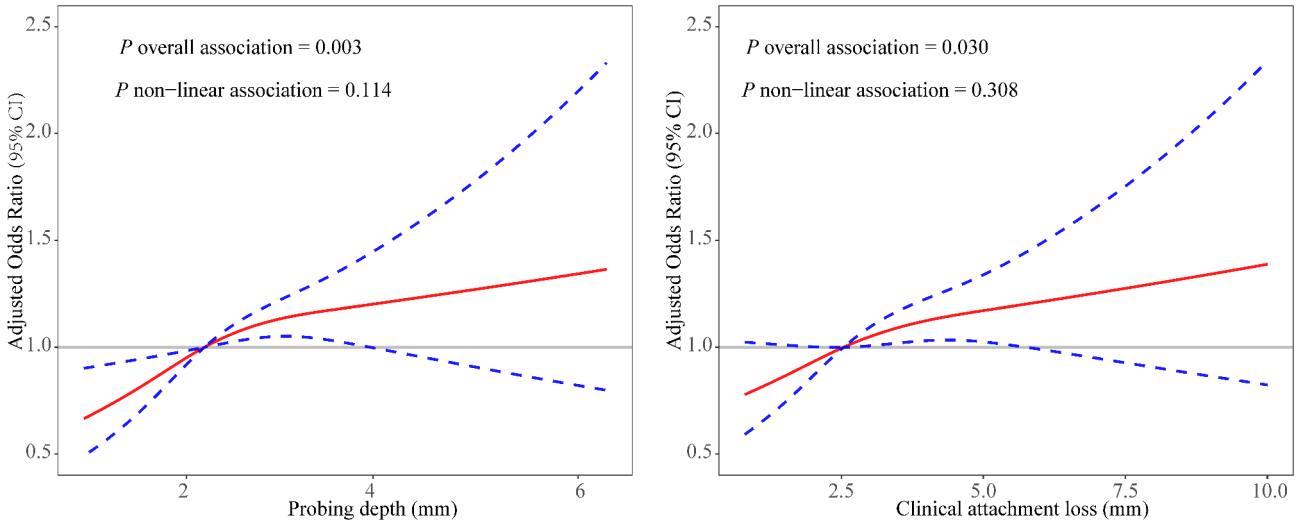

Fig. 2. Restricted cubic spline for associations of PD/CAL with arterial stiffening. Point estimates (solid line) and 95% confidence intervals (dashed lines) were depicted by restricted cubic spline models with knots at the 10th, 50th, and 90th percentiles. All models were adjusted for age, sex, ethnicity, marital status, education, smoking, body mass index, total cholesterol/high density lipoprotein cholesterol, eGFR, diabetes, mean arterial pressure, white blood cell, monocyte, neutrophil, and lymphocyte.

Subgroup	No/Mild Periodontitis OR(95% CI)	Moderate Periodontitis OR(95% CI)	Severe Periodontitis OR(95% CI)	^{P} for trend
Diabetes				
Absence	Ref	1.29(1.04–1.60)*	1.40(1.04–1.90)*	0.011
Presence	Ref	1.30(0.94–1.81)	1.15(0.73–1.81)	0.356
Chronic kidney disease				
Absence	Ref	1.40(1.04–1.90)**	1.48(1.14–1.93)**	0.001
Presence	Ref	1.16(0.74–1.83)	0.80(0.39–1.65)	0.867

Table 4. Multivariate logistic regression models for associations between periodontitis severity and arterial stiffening (Pulse pressure ≥ 60) by subgroups stratified by diabetes or chronic kidney disease. Model covariates were age, sex, ethnicity, marital status, education, smoking, body mass index, total cholesterol/high density lipoprotein cholesterol, eGFR, diabetes, mean arterial pressure, white blood cell, monocyte, neutrophil, and lymphocyte. OR(95% CI), odds ratio and 95% confidence interval. Chronic kidney disease was defined as eGFR < 60mL/(min·1.73m^2). *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

association between the severity of periodontitis and arterial stiffening even after adjusting for mean arterial pressure.

Diabetes and renal insufficiency are important factors affecting the progression of arterial stiffening. Previous studies have not found a association between periodontitis and arterial stiffening in diabetic patients[42]. Previous study has shown that the level of advanced glycosylation end products is increased significantly in diabetic patients and correlated with cfPWV independently, independent of age, gender, blood pressure and renal function[43]. Meta-analysis results also provide evidence that DM is significantly and independently associated with cfPWV[44]. Additionally, CKD serves as an independent risk factor for arteriosclerosis. In our study, there was no significant association between the severity of periodontitis and arterial stiffening in the subgroup of patients with hypertension combined with diabetes or renal dysfunction.

In recent years, there has been increasing attention on the association between periodontitis and various diseases, some of which have high prevalence rates in the general population, such as cardiovascular disease and diabetes. Effective periodontal treatment can not only improve the quality of life of patients, reduce the levels of inflammatory factors, reduce the risk of arterial stiffening disease, improve metabolic control, and reduce the occurrence of diabetic complications[3,45], but also may bring clinical benefits to cardiovascular and metabolic diseases. This underscores the clinical significance of evaluating patients' periodontal status in comprehensive risk assessments, given that screening and treatment for periodontal disease are readily available and cost-effective[46]. The additional benefit of oral therapy may increase the willingness and compliance of patients with periodontal disease. Therefore, the cooperation between clinicians and stomatologists should be strengthened to strengthen the screening and treatment of periodontitis.

At present, there is a paucity of research on the association between periodontitis and arterial stiffening, with existing studies having relatively small sample sizes that result in inadequate assessment of arteriosclerosis in patients with periodontitis. This study, for the first time, focused on a larger sample of hypertensive patients, adjusted for confounding factors such as mean arterial pressure, to explore the relationship between the severity of periodontitis and arterial stiffening. Furthermore, this study examined the relationship between components of periodontitis, namely PD and CAL, and arterial stiffening. However, this study may have some limitations. The cross-sectional design precludes inference of causal relationships between variables; thus further research is necessary to confirm any associations identified. Additionally, the absence of other inflammatory markers such as IL-1, IL-6, TNF, and high-sensitivity CRP may limit a comprehensive reflection of inflammation levels within the sample population.

Conclusion

The findings of this cross-sectional study suggest the association between periodontitis and arterial stiffening in hypertensive individuals aged 50 and older. The identification and management of periodontitis may provide additional clinical advantages.

Data availability

The data utilized in this study are sourced from a publicly available NHANES database (https://www.cdc.gov/nchs/nhanes/index.htm), accessible to all through the provided links.

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Author contributions

Hu C and Zhang H designed the study, performed the statistical analysis and drafted the manuscript. Qi G acquired data and participated in drafting the manuscript. Tian W conceived of the study, and participated in its design, helped to draft the manuscript, and provided critical revision for important intellectual content.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The survey protocol received approval from the NCHS Ethics Review Board (https://www.cdc.gov/nchs/nhanes/irba98.htm), and all participants have written informed consent.

Additional information

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