Association Between Periodontitis and Chronic Obstructive Pulmonary Disease in a Chinese Population

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Background: A relationship between periodontitis and chronic respiratory disease has been suggested by recent studies. The aim of this study is to explore the association between periodontitis and chronic obstructive pulmonary disease (COPD) in a Chinese population.

Methods: We conducted a case-control study of 581 COPD cases and 438 non-COPD controls. Lung function examination, a 6-minute walk test, and the British Medical Research Council questionnaire were performed. Periodontal clinical examination index included probing depth (PD), attachment loss (AL), bleeding index (BI), plaque index (PI), and alveolar bone loss. A validated index for predicting COPD prognosis, the body mass index, airflow obstruction, dyspnea, and exercise capacity (BODE) index, was also calculated.

Results: Participants with more severe COPD were more likely to have severe periodontal disease. PD, AL, PI, alveolar bone loss, and the number of teeth were significantly associated with all stages of COPD (all $P<0.001$). When compared to controls (BODE = 0), participants with higher BODE scores had significantly higher AL ($P<0.001$), BI ($P = 0.027$), PI ($P<0.001$), alveolar bone loss ($P<0.001$), and the number of teeth ($P<0.001$). PI appeared to be the main periodontal health-related factor for COPD, with an odds ratio (OR) = 9.01 (95% CI = 3.98 to 20.4) in the entire study population OR = 8.28 (95% CI = 2.36 to 29.0), OR = 5.89 (95% CI = 2.64 to 13.1), and OR = 2.46 (95% CI = 1.47 to 4.10) for current, smokers, and non-smokers, respectively.

Conclusion: Our study found a strong association between periodontitis and COPD, and PI seemed to be a major periodontal factor for predicting COPD among Chinese adults. *J Periodontol 2012;83:1288-1296.*

KEY WORDS

Periodontitis; pulmonary disease, chronic obstructive; respiratory function tests.

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Chronic obstructive pulmonary disease (COPD) is a major global health problem and is a main cause of death and disability worldwide.[1] COPD patients have a compromised life quality and high mortality rate.[2,3] COPD is the fourth leading cause of death in the world, and its prevalence and mortality are expected to increase in the coming decades.[4] A COPD patient is characterized by irreversible airflow limitation, which is usually progressive and caused by an abnormal inflammatory response of the lung to noxious particles or gases.[5] Bacterial infection and smoking are typically considered as main risk factors for COPD.[6]

Periodontitis is also a highly prevalent health problem and manifests as a chronic inflammatory reaction to bacterial infections. Periodontitis is a destructive disease that affects the tooth-supporting tissues and ultimately leads to tooth loss in 15% of adults.[7] The results of the Third National Oral Health Survey of the Ministry of Health, China, showed that the prevalence of healthy periodontal status was only 14.5% for adults 35 to 44 years old and 14.1% for those 65 to 74 years old.[8] Only one seventh of the middle-aged and older adult population had no gingival bleeding, no deep pocket, and no attachment loss (AL) of <3 mm, which indicated the widespread occurrence of periodontitis in China.[8]

Recent research has suggested that periodontitis not only causes gingival

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bleeding but also is a risk factor for systemic inflammation-related chronic diseases, such as cardiovascular disease,[9-11] diabetes, and COPD.[12-14] Previous studies have also shown an association between poor oral health and COPD, independent of other confounding variables, such as age, sex, and smoking.[15,16] Patients with COPD were found to have more mean clinical AL than those without COPD, and the oral hygiene scores and percentage of gingival bleeding sites were significantly associated with the severity of COPD.[17] At least one prospective study found that the risk of COPD in participants who were current smokers significantly increased with the severity of periodontal disease.[18] However, the evidence has been inconclusive because of limited data.

We conducted a case-control study involving large numbers of cases and controls with multiple metrics of lung function and COPD prognostic factors in a Chinese population to further investigate the relationship between periodontitis and COPD.

MATERIALS AND METHODS

Study Population

Participants of this multicenter study were enrolled from outpatients >30 years old (640 males and 379 females; mean age: 63.39 ± 9.44 years) receiving health care at the Departments of Respiratory Medicine (patients with COPD; n = 581) and Departments of Dentistry (controls; n = 438) in eight hospitals in Beijing, China. Consecutive patients were enrolled from March 2007 to December 2009. Patients were not eligible for the study if they had: 1) < 15 teeth; 2) experienced exacerbations of COPD symptoms (including cough or expectoration, pyrexia, or aggravation of dyspnea); or 3) changed medication use as a result of respiratory symptoms within 4 weeks before recruitment. Patients who met the eligibility criteria, and were willing to participate, signed a consent form. The study protocol was approved by the human research ethical board from Beijing ChaoYang Hospital, Beijing, China.

A pretest was performed in a small population similar to the sample of this study to find out if any questions might be unclear, and determine if the structure of the questionnaire was acceptable. The useful information was collected and the draft of the questionnaire was revised with care on wording and content. The questionnaire included demographic variables, such as age, sex, marital status, occupation, educational level, living condition, smoking status and number of cigarettes smoked daily. The British Medical Research Council (MRC)[19] questionnaire was also completed.

Evaluation of Periodontal Status

The oral examinations were performed by two examiners (XZ, JZ), who had received training by an experienced dentist (ZW). Replicate examinations were conducted throughout the study to assess intra-examiner reliability. The κ value of intra-examiner agreement was 0.82. The periodontal examination included probing depth (PD), AL, bleeding index (BI),[20] and plaque index (PI),[21]. BI was scored on a 0 to 5 scale, and PI was determined on a 0 to 3 scale after air drying. The four indices were recorded on six sites of each tooth. The highest scores of buccal and lingual surfaces were recorded separately, and then the higher of the two was used for analysis. A full-mouth series of intraoral periapical radiographs were used to assess the level of alveolar bone loss (ABL), with a score of 0 (without ABL), 1 (ABL <1/3 of the root in length), 2 (ABL from 1/3 to 2/3 of the root in length), or 3 (ABL >2/3 of the root in length) assigned to each tooth.[22]

According to the classification of periodontitis used in the US Third National Health and Nutrition Examination Survey,[23] the participants were divided into three groups: 1) mild periodontitis (n = 232), ≥1 teeth with ≥3 mm PD, <30% of the teeth examined having ≥4 mm PD, and no teeth having ≥5 mm PD; 2) moderate periodontitis (n = 351), ≥1 teeth with ≥5 mm PD or 30% to 60% of the teeth examined having ≥4 mm PD; or 3) severe periodontitis (n = 436), ≥30% of the teeth examined having ≥5 mm PD or ≥60% of the teeth examined having ≥4 mm PD.

Test of Lung Function

Lung function of each participant was measured using spirometry and presented as percentage of forced expiratory volume in 1 second (FEV_1) over predicted value and the ratio of FEV_1/forced vital capacity (FEV_1/FVC). The control group was in accordance with the criteria of FEV_1/FVC >0.70, and all patients with COPD were clinically diagnosed and confirmed by lung function examination. Severity of patients with COPD was classified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) definition:[6,24,25] 1) mild (stage I; FEV_1/FVC <0.70, and FEV_1 ≥80% predicted); 2) moderate (stage FEV_1/FVC <0.70 and FEV_1 from 50% to 80% predicted II;); 3) severe (stage III; FEV_1/FVC <0.70 and FEV_1 from 30% to 50% predicted.); or 4) very severe (stage I FEV_1/FVC <0.70 and FEV_1 <30% predicted or FEV_1 <50% predicted plus chronic respiratory failure V;). Stage I is . Respiratory failure is defined as arterial partial pressure of oxygen <8.0 kPa (60 mmHg) with or without arterial partial pressure of CO_2 ($PaCO_2$) >6.7 kPa (50 mm/Hg) while breathing air at sea level.

All patients underwent a 6-minute walk test (6MWT), which is recognized as a simple and reliable method to evaluate lung function and prognosis of COPD.[26]

The MRC questionnaire[27] to assess the severity of breathlessness was also used. A score ranging from 0 ("I only get breathless with strenuous exercise") to 4 ("I am too breathless to leave the house or I am breathless when dressing or undressing")[27,28] was recorded for each patient(score 0:434 [42.6%]patients ; score 1: 303[29.7%]; score 2177 [17.4%]; score 3:66 [6.5%]; and score 4: 39 [3.8%]).

Finally, the body mass index (BMI), airflow obstruction, dyspnea, and exercise capacity (BODE)[29] index, a multidimensional grading system that simultaneously considers airflow obstruction (using FEV_1), dyspnea (using MRC score), and exercise capacity (using 6-minute walking distance), a validated tool (BODE)[30-32] to help predict COPD prognosis was applied. The criteria for scoring the BODE index is described in Table 1.[29] The BODE score of each participant is the sum of thefour variables with scores ranging from 0 to 10, with higher scores indicating more severe COPD prognosis.

Participants were divided into four groups: 1) BODE = 0 (n = 429); 2) BODE = 1 or 2 (n = 320); 3) BODE = 3 or 4 (n = 180); and 4) BODE ≥5 (n = 90). The latter 3 groups could then be combined to one group: BODE >0 (n = 590).

Statistics Analyses

A statistical software package‖ was used for data analyses. A two-sided *P* value <0.05 was considered to be statistically significant. Independent-samples *t* test was used to compare continuous variables, and χ^2 test was used to compare categorical variables between the COPD and non-COPD groups. One-way analysis of variance (ANOVA) was used to compare the periodontal status among different COPD stages and different BODE scores. Pearson correlation coefficients between lung function index and periodontal index were computed.

Logistic regression analysis was performed to assess the odds ratio (OR) and 95% confidence interval (CI) of COPD in association with periodontal health status. The covariates included demographic variables, smoking status, and BMI. BODE score was considered as the dependent variable, participants were also stratified by smoking status.

RESULTS

Demographic characteristics of the study population are summarized in Table 2. The mean ± SD age of participants was 63.4 ± 9.4 years, and mean ± SD BMI was 25.0 ± 4.05. Patients with COPD were more likely to be men, current or former smokers, or had lower education; there were no statistical differences between age, BMI, marital status, and living condition between the two groups.

Table 1.

Criteria of Scoring BODE Index

BODE Index of COPD[29]	0	1	2	3
FEV_1 (% predicted)	≥65	50 to 64	36 to 49	≤35
6MWT (m)	≥350	250 to 349	150 to 249	≤149
MRC score	0 to 1	2	3	4
BMI (kg/m^2)	>21	≤21	NA	NA

NA = not applicable.

Participants were divided into three groups according to severity of periodontitis, and patients with COPD were classified into four groups according to severity of COPD (Table 3). Overall, participants with more severe COPD were more likely to have severe periodontal disease.

The mean PI, AL, ABL, number of teeth, and percentage of patients with PD ≥4 mm and AL ≥3 mm were higher in COPD group than in control group, and these indexes increased with severity of COPD. The difference among the different stages of COPD was statistically significant (P <0.001), which implied that the patients with more severe COPD would have higher PD value and higher percentage of patients with PD ≥5 mm and AL ≥4 mm (Table 4). Patients with higher BODE scores had significantly higher BI, PI, AL, ABL, and less number of teeth.

The correlation coefficients between periodontal index and lung function index are presented in Table 5. The periodontal indicesPD, PI, AL, and ABL were negatively correlated with FEV_1% predicted and FEV_1/FVC, but positively correlated with MRC and BODE scores. Number of teeth was positively correlated with FEV_1% predicted, FEV_1/FVC, and 6MWT but negatively correlated with MRC and BODE scores. PD was negatively correlated with FEV_1% predicted and FEV_1/FVC, but not correlated with other lung function indices.

Logistic regression analysis showed that PI was the main periodontal health-related factor for COPD (Table 6). After adjusting for age, sex, occupation, educational level, and smoking status, the COPD OR = 9.01 (95% CI = 3.98 to 20.4) for PI in the entire sample. When stratified by smoking status, the OR = 8.28 (95% CI = 2.36 to 29.0) among current smokers, OR = 5.89 (95% CI = 2.64 to 13.1) among former smokers, and OR = 2.46 (95% CI = 1.47 to 4.10) among non-smokers. Other periodontal indexes also related to COPD, such as AL (OR = 1.41 in the entire sample, OR = 1.59 in former smokers) and ABL (OR = 3.89 in non-smokers) can be seen in Table 6.

‖ SPSS statistical package, v.12.0, IBM, Chicago, IL.

Table 2.

Basic Demographic and Lifestyle Characteristics of Participants

Demographic Variables	Control Group (n = 438)	COPD Group (n = 581)	*P* Value
Age (mean ± SD)	62.8 ± 9.5	63.9 ± 9.4	0.06*
Sex			<0.001†
Female	220 (50.2%)	159 (27.4%)	
Male	218 (49.8%)	422 (72,6%)	
Marital status			0.10†
Married	391 (89.3%)	537 (92.4%)	
Unmarried, divorced, or widowed	47 (10.7%)	44 (7.6%)	
Occupation			<0.001†
Worker	114 (26.0%)	251 (43.2%)	
Academic faculty/teacher	124 (28.3%)	130 (22.4%)	
Technician	112 (25.6%)	125 (21.5%)	
Other occupation	88 (20.1%)	75 (12.9%)	
Educational level‡			<0.001†
Primary school or below	49 (11.2%)	113 (19.4%)	
Middle school	80 (18.3%)	187 (32.2%)	
Senior high school	119 (27.2%)	114 (24.3%)	
College or above	190 (43.4%)	140 (24.1%)	
Living condition§			0.09†
Living alone	43 (13.4%)	55 (17.0%)	
Living with family	55 (17.2%)	167 (51.5%)	
Smoking status			<0.001†
Current smoker	49 (11.2%)	113 (19.4%)	
Former smoker	76 (17.4%)	294 (50.6%)	
Non-smoker	313 (71.5%)	174 (29.9%)	
BMI (mean ± SD)	25.1 ± 3.8	24.9 ± 4.2	0.54*

* *P* value obtained from independent-samples *t* test.
† *P* value obtained from χ^2 test.
‡ 27 patients not included due to missing values.
§ Only patients without missing variable values included.

DISCUSSION

In this study, a strong association between periodontitis and COPD was shown. The results showed that individuals with higher BODE scores had significantly higher BI, PI, AL, ABL, and less number of teeth. This study also showed that PI was the main periodontal health-related factor for COPD. These findings indicate the importance of promoting oral hygiene in the prevention and treatment of COPD.

BODE is a multidimensional grading system evaluating patients with COPD that was initially proposed in 2004[29] and has been widely used in recent years.[30-32] Classification of COPD according to the GOLD definition is based on post-bronchodilator FEV_1. The aggregative indicator (BODE) includes BMI, airflow obstruction, dyspnea, and exercise capacity. In addition to FEV_1, BODE also includes other physiologic and clinical variables, so it could reflect general characteristics of COPD, and the accuracy of mortality prognosis using BODE is better than using FEV_1 only.[29] In this study of a Chinese population, the results from BODE are similar to the results of traditional classification of COPD stages, so BODE proved to be a good indicator for evaluating COPD, reflecting the aggregative conditions of patients with COPD, and is also suitable for analyzing

Table 3.

Crude Distribution of Periodontal Status by Group

Periodontal Status	Control Group	COPD Group Severity						*P*†
		COPD	*P**	Stage I	Stage II	Stage III	Stage IV	
Mild	159 (36.3%)	73 (12.6%)		20 (24.7%)	26 (9.8%)	20 (11.6%)	7 (10.9%)	
Moderate	86 (19.6%)	265 (45.6%)		43 (53.1%)	159 (60.2%)	57 (33.1%)	6 (9.4%)	
Severe	193 (44.1%)	243 (41.8%)		18 (22.2%)	79 (29.9%)	95 (55.2%)	51 (79.7%)	
Total	438 (100%)	581 (100%)	<0.001	81 (100%)	264 (100%)	172 (100%)	64 (100%)	<0.001

* *P* value obtained from χ^2 test for comparing the distribution of periodontitis between control and COPD groups.
† *P* value obtained from χ^2 test for comparing the distribution of periodontitis among different COPD groups.

Table 4.

Periodontal Status by Group

Periodontal Indicator	COPD Stages									BODE Scores					
		COPD Groups								BODE >0 Groups					
	Control Group (n = 438)	COPD (n = 581)	P*	Stage I (n = 81)	Stage II (n = 264)	Stage III (n = 172)	Stage IV (n = 64)	P†	BODE = 0 (n = 429)	BODE > 0 (n = 590)	P‡	BODE = 1 or 2 (n = 320)	BODE = 3 or 4 (n = 180)	BODE ≥5 (n = 90)	P§
PD (mm)	3.45 ± 0.92	3.54 ± 0.71	0.07	3.41 ± 0.55	3.54 ± 0.65	3.42 ± 0.63	4.00 ± 1.05	<0.001	3.51 ± 0.87	3.48 ± 0.76	0.58	3.45 ± 0.75	3.46 ± 0.66	3.68 ± 0.94	0.084
BI	2.59 ± 0.68	2.60 ± 0.61	0.85	2.72 ± 0.63	2.59 ± 0.56	2.51 ± 0.63	2.69 ± 0.73	0.09	2.66 ± 0.62	2.54 ± 0.65	0.003	2.53 ± 0.64	2.55 ± 0.65	2.55 ± 0.69	0.03
PI	2.56 ± 0.44	2.79 ± 0.29	<0.001	2.66 ± 0.35	2.78 ± 0.30	2.84 ± 0.24	2.88 ± 0.21	<0.001	2.58 ± 0.42	2.77 ± 0.32	<0.001	2.71 ± 0.36	2.82 ± 0.28	2.88 ± 0.18	<0.001
AL (mm)	4.87 ± 1.83	5.52 ± 1.55	<0.001	5.03 ± 1.28	5.54 ± 1.39	5.54 ± 1.52	5.97 ± 2.28	<0.001	4.93 ± 1.78	5.46 ± 1.62	<0.001	5.21 ± 1.53	5.66 ± 1.50	5.96 ± 1.97	<0.001
ABL	1.30 ± 0.41	1.49 ± 0.45	<0.001	1.35 ± 0.31	1.51 ± 0.44	1.47 ± 0.45	1.7 ± 0.58	<0.001	1.32 ± 0.42	1.47 ± 0.45	<0.001	1.4 ± 0.39	1.53 ± 0.47	1.61 ± 0.55	<0.001
Number of teeth	24.39 ± 6.00	23.02 ± 6.48	0.001	25.21 ± 3.93	23.04 ± 6.29	22.41 ± 6.98	21.77 ± 7.77	<0.001	24.51 ± 5.94	22.95 ± 6.49	<0.001	24.04 ± 5.56	22.52 ± 6.69	19.94 ± 8.01	<0.001
PD ≥5 mm and AL ≥4 mm (%)	18.33 ± 0.23	19.90 ± 0.20	0.24	15.61 ± 0.14	19.48 ± 0.17	16.27 ± 0.16	36.84 ± 0.33	<0.001	18.91 ± 0.22	19.45 ± 0.20	0.69	18.38 ± 0.19	18.55 ± 0.17	25.09 ± 0.30	0.05
PD ≥4 mm and AL ≥3 mm (%)	36.78 ± 0.30	42.81 ± 0.25	<0.001	38.75 ± 0.21	43.97 ± 0.23	38.18 ± 0.25	55.58 ± 0.34	<0.001	39.02 ± 0.28	41.09 ± 0.27	0.23	39.71 ± 0.26	40.64 ± 0.26	46.89 ± 0.31	0.10

* P value obtained from independent t test for comparing indexes of periodontitis between control and COPD groups.
† P value obtained from one-way ANOVA for comparing indexes of periodontitis among different COPD stages.
‡ P value obtained from independent t test for comparing indexes of periodontitis between BODE = 0 group and BODE > 0 group.
§ P value obtained from one-way ANOVA for comparing indexes of periodontitis among different BODE scores.

the relationship between periodontitis and COPD.

Previous research has suggested an association between poor oral hygiene, periodontitis, and chronic respiratory diseases such as COPD.[12,33] The study of Hayes et al.[34] found that the level of ABLassessed by periapical radiographs was independently associated with COPD. Scanapieco and Ho.[12] performed a retrospective study of 13,792 individuals ≥20 years old with ≥6 natural teeth; the results showed that individuals with COPD had higher AL than those without COPD, and the individuals with mean AL ≥3.0 mm had a higher odds of COPD than those with mean AL <3.0 mm (OR = 1.45). In a prospective study[18] of 1,112 participants followed up to 30 years, participants in the increasing quintile of worse periodontal health at baseline had greater risk for developing COPD. Some studies reported that periodontitis was common in patients with severe COPD,[17,35] and poor periodontal health was associated with an increased severity of COPD.[17] A recent Indian study[17] also showed that the higher mean AL, the higher likelihood of COPD. Leuckfeld et al.[35] reported that mean marginal bone level ≥4 mm was significantly associated with severe COPD. We have reported previously in a Chinese population that patients having less healthy oral behavior and poor oral health knowledge were more likely to have COPD.[36] The present study expands our previous findings to a larger sample and shows consistent and strong relationship between multiple periodontal indices and COPD status. When compared to participants with a BODE score of 0, participants with higher BODE scores had significantly higher BI, AL, PI, ABL, and less number of teeth. Mean of PD, AL, PI, ABL, less number of teeth, percentage of PD ≥4 mm and AL ≥3 mm, and percentage of PD ≥5 mm and AL ≥4 mm significantly increased with increasing severity of COPD.

In this study, PI was found the main periodontal health-related factor for COPD. Plaque accumulation is clearly an essential initial etiological factor in periodontitis, although the exact mechanism for the relationship between oral hygiene and COPD remains unclear. Some

Table 5.

Correlations Between Periodontal Status and Lung Function Measures Among Patients With COPD

	FEV_1 (% Predicted)		FEV_1/FVC		MRC Score		6MWD		BODE Score	
Periodontal Status	Pearson Correlation Coefficient	*P* Value*	Pearson Correlation Coefficient	*P* Value*	Spearman Correlation Coefficient	*P* Value*	Pearson Correlation Coefficient	*P* Value*	Spearman Correlation Coefficient	*P* Value*
PD (mm)	−0.081	0.01†	−0.071	0.02†	0.046	0.28	0.031	0.33	0.039	0.22
BI	0.037	0.24	0.021	0.51	−0.030	0.32	0.020	0.52	−0.056	0.07
PI	−0.345	<0.001§	−0.354	<0.001§	0.261	<0.001§	0.040	0.21	0.271	<0.001§
AL (mm)	−0.182	<0.001§	−0.207	<0.001§	0.171	<0.001§	−0.053	0.09	0.191	<0.001§
ABL	−0.216	<0.001§	−0.225	<0.001§	0.161	<0.001§	−0.088	0.006‡	0.202	<0.001§
Number of teeth	0.155	<0.001§	0.129	<0.001§	−0.136	<0.001§	0.109	0.001‡	−0.184	<0.001§
PD ≥5 mm and AL ≥4 mm (%)	−0.090	0.004‡	−0.068	0.03†	0.084	0.24	0.020	0.53	0.058	0.06
PD ≥4 mm and AL ≥3 mm (%)	−0.122	<0.001§	−0.117	<0.001§	0.066	0.03†	0.016	0.61	0.075	0.02†

* *P* value obtained from bivariate Pearson correlation analysis.
† ≤0.01; *P* <0.05.
‡ ≤0.001; *P* <0.01.
§ *P* <0.001.

hypotheses suggest that bacteria in oral cavity may be aspirated along with respiratory pathogens and affect adhesion of the later organisms to the respiratory epithelium, which subsequently cause lung disease.[16] Dental plaque may also provide nutrition to the pathogens in respiratory tract, especially in patients with poor oral hygiene.[3] Periodontal disease may alter environmental conditions to permit mucosal colonization and infection by respiratory pathogens.[34,37] Aspiration of oral pharyngeal contents, such as food particles and saliva rich in bacteria, would link periodontitis and respiratory infections.[38] Concentration of bacteria in saliva is very high, and species of bacteria in oral cavity has been found in the lungs of patients with COPD.[39] Some trials have shown that the risk for respiratory disease and infection of lower respiratory tract could be reduced through improving oral hygiene and decreasing the bacteria level in oral cavity.[17,40]

It is possible that periodontal conditions combine with other factors, such as smoking, environmental pollutants, allergies, and genetics, to contribute to the progression of COPD.[17] Cigarette smoking is the most important and a well-accepted risk factor for COPD.[12] Smoking is also a major risk factor for periodontitis. Therefore, smoking could be either a confounder or an effect modifier in the relationship between periodontitis and COPD.[41] Katancik et al.[42] found that AL was higher in patients with COPD than in the control group, especially among former smokers. Hyman et al.[41] reported that current smokers with AL ≥4 mm had a high odds of COPD (OR = 3.71). In the current study, to address the interaction among cigarette smoking status, periodontal disease, and COPD, analysis was stratified by smoking status. The results showed that periodontal indices (BI, PI, AL, and number of teeth) were significantly associated with BODE scores among former smokers, and higher PI was associated with a high odds of COPD among current smokers.

The present case-control study is the first comprehensive analysis of the association between periodontitis and COPD in a Chinese population. The results

Table 6.

ORs of COPD in Relation to Periodontal Health in all Participants and Stratified by Cigarette Smoking Status

Covariates Entered in the Models	Adjusted OR	95% CI		*P* Value*
		Lower	Upper	
All participants				
Smoking status	0.48	0.27	0.85	0.01†
Total smoking quantity	1.01	1.00	1.01	0.05†
PD	0.19	0.07	0.50	0.001‡
PI	9.01	3.98	20.40	<0.001§
AL	1.41	1.09	1.84	0.01†
Current smokers				
PI	8.28	2.36	29.00	0.001
PD ≥5 mm and AL ≥4 mm (%)	0.16	0.03	0.84	0.03
Former smokers				
BI	0.23	0.13	0.41	<0.001
PI	5.89	2.64	13.12	<0.001§
AL	1.59	1.24	2.02	<0.001§
Number of teeth	1.07	1.02	1.13	0.006‡
Non-smokers				
PI	2.46	1.47	4.10	0.001‡
ABL	3.89	2.00	7.57	<0.001§
PD ≥5 mm and AL ≥4 mm (%)	0.19	0.06	0.64	0.007‡
BMI	0.83	0.78	0.88	<0.001§

* *P* value obtained from logistic regression analysis (with age, sex, occupation, educational level, and smoking status adjusted).
† $P<0.05$.
‡ $0.001 \leq P<0.01$.
§ $P<0.001$.

indicated the importance of promoting oral hygiene in the prevention and treatment of both diseases. Such data, if confirmed by future prospective studies, would provide valuable information for the planning of oral health care for patients with COPD. The authors also hope that this study will stimulate and support future function studies to offer new insights into the pathogenic mechanisms underlying the relationship of periodontal health and COPD.

There are several limitations that deserve to be considered. First, Berkson's bias existed in this study, which is a type of selection bias, and may occur in retrospective case-control studies based entirely on hospital cases and controls. Second, the causality cannot be inferred from this study because of its observational and retrospective study design. Third, this study cannot completely exclude the possibility of residual confounding by other healthy lifestyle variables and comorbid disease. In addition, measurment errors of periodontal and pulmonary variables could have attenuated the results.

CONCLUSIONS

In conclusion, a strong association between periodontitis and COPD was found. The results showed that individuals with higher BODE scores had significantly higher BI, PI, AL, ABL, and less number of teeth. These findings indicate the potential importance of promoting oral hygiene in the prevention and treatment of COPD, although additional studies are needed to clarify the causal relationship between periodontitis and COPD and explore the biologic mechanisms underlying the observed association.

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