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Periodontal health, oral health behaviours, and chronic obstructive pulmonary disease

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Abstract

Aim: To evaluate the associations of periodontal health status and oral health behaviours with chronic obstructive pulmonary disease (COPD).

Materials and Methods: We conducted a case–control study of 306 COPD patients and 328 controls with normal pulmonary function. Their periodontal status and respiratory function were clinically examined and information on oral health behaviours was obtained using a validated questionnaire.

Results: Patients with COPD had fewer teeth and a higher plaque index than the controls. Univariate analysis showed that tooth brushing times and method, experience of dental floss use, dental visit and regular supra-gingival scaling, and oral health knowledge were significantly related to the risk of COPD. After adjusting for age, sex, and body mass index and stratifying by smoking status, inappropriate tooth brushing method ($p = 0.025$ among non-smokers), lower regular supra-gingival scaling ($p = 0.027$ among non-smokers and $p < 0.0001$ among former smokers), and poorer oral health knowledge ($p < 0.0001$ among non-smokers and $p = 0.019$ among former smokers and $p = 0.044$ among current smokers) remained significantly associated with COPD.

Conclusions: Poor periodontal health, dental care, and oral health knowledge were significantly associated with an increased risk of COPD. Our findings indicate the importance of promoting dental care and oral health knowledge that can be integrated into the prevention and treatment of COPD.

Key words: case–control study; Chinese subjects; chronic obstructive pulmonary disease; oral health; periodontitis; risk factors

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Conflict of interest and source of funding statement

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Chronic obstructive pulmonary disease (COPD) is one of the most common and costly respiratory diseases. The high prevalence and mortality of COPD worldwide pose an immense public health and medical challenge for the implementation of effective preventive and treatment strategies (Murray & Lopez 1997). The aetiology of COPD is complex and multifactorial, involving multiple genetic and environmental factors such as smoking and air pollution (Rabe et al. 2007). Periodontitis is a chronic inflammatory reaction to bacterial infections that results in the destruction of the supporting connective tissue and bone of the dentition. Oral pathogens and inflammatory cytokines from periodontal lesions induce systemic inflammation, which may contribute to the pathogenesis of COPD (Terpenning 2001).

Recent reports have implicated that periodontitis is associated with several other diseases including type 2 diabetes mellitus, cardiovascular disease, and respiratory system diseases (Ryan et al. 2003, Taylor 2003, Seymour et al. 2007). Three cross-sectional epidemiological studies suggested an association between poor oral health (including oral hygiene index, alveolar bone loss, and periodontal attachment loss) and chronic pulmonary disease (Hayes et al. 1998, Scannapieco et al. 1998, Scannapieco & Ho 2001),

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although the precise mechanisms underlying such relationships remain unclear. A weak association between periodontal disease and COPD has also been described (Scannapieco et al. 2003, Katancik et al. 2005, Azarpazhooh & Leake 2006). One case–control study reported a significant association between periodontal disease and airway obstruction, particularly in former smokers (Kowalski et al. 2005); another study suggested that worse periodontal diseases significantly increased the risk of COPD in subjects who were current smokers (Garcia et al. 2001). Didilescu et al.'s (2005) study indicated that dental plaque in patients with chronic lung diseases often serves as a reservoir of bacteria known to cause nosocomial pneumonia in susceptible individuals. Because of limited data, little is known about the relation of oral health care with COPD. Therefore, we conducted a case–control study to examine the relation of periodontal health status and oral health-related behaviours with the risk of COPD in a Chinese population.

Materials and Methods

Study population

We conducted a case–control study in which a total of 306 COPD patients and 328 participants with normal pulmonary function were recruited from Beijing ChaoYang hospital and other seven hospitals in Beijing. From March 2007 to November 2008, consecutive patients who were 30 years of age or older were recruited. The patients should have more than 15 teeth, all in stable stage and have no exacerbations of symptoms in the past 1 month at recruitment (Rabe et al. 2007). All COPD cases were clinically diagnosed and confirmed by lung function examination. Controls were randomly selected from all eligible patients with normal lung function in the same hospitals. All participants were interviewed at recruitment by trained interviewers.

The human research ethnical board from Beijing ChaoYang hospital approved the study, and written informed consent was obtained from all the participants.

Periodontal examination

The oral health examinations were conducted by two trained dentists who were blinded to the study design and patients COPD status. Replicate examinations were conducted throughout the survey to repeatedly assess intra-examiner reliability. The κ value of agreement was 0.82. The evaluation included periodontal probing, oral hygiene, number of teeth present, and X-ray examination of alveolar bone. Periodontal probing included probing depth (PD), location of the cemento-enamel junction (CEJ) to determine clinical attachment level (CAL), and bleeding index (BI) on probing. PD and CEJ were measured with a Williams periodontal probe at six sites of all teeth (excluding third molars) and recorded in millimetres. Recession was recorded as a positive value if the free gingival margin occurred apical to the CEJ, whereas it was recoded as a negative value if it was coronal to the CEJ. CAL was calculated using the formula PD+CEJ = CAL. BI on probing was scored on a 0–5 scale when any visual evidence of bleeding was noted (Mazza et al. 1981). The plaque index (PLI) for each tooth was determined on a 0–3 scale after air drying (Silness & Löe 1964). Alveolar bone loss was examined using full-mouth series of intra-oral periapical films. Bone loss at each mesial and distal interproximal site was assessed: 1 = alveolar bone loss less than 1/3 of the root in length; 2 = alveolar bone loss between 1/3 and 2/3 of the root in length; and 3 = alveolar bone loss more than 2/3 of the root in length. Dental caries and oral mucosal were also evaluated.

Diagnosis of COPD and assessment of lung function

The criteria used for the diagnosis of COPD are based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometry guidelines: Global Strategy for the Diagnosis, Management, and Prevention of COPD (update 2007) (Rabe et al. 2007).

Lung function was measured using spirometry. The spirometric measurements were conducted by trained and certified technicians. During at least five forced expirations, the technician attempted to obtain three acceptable spirograms, at least two of which showed similar results for forced expiratory volume (FEV) in 1 s (FEV_1) and forced vital capacity (FVC). The pulmonary evaluation was based on the FEV_1/FVC and then used the percent of predicted FEV_1 to categorize severity. Air limitation was defined using the fixed ratio post-bronchodilator FEV_1/FVC < 0.70.

Measurement of oral health behaviour-related variables

Detailed information on oral health behaviours was obtained using a standardized questionnaire as validated and widely used in a Chinese National Oral Health Epidemiology Survey (Qi et al. 2008). The questionnaire included tooth brushing times, tooth brushing methods, dental floss use, frequency of dental visits, periodontal treatment, and assessment of oral health knowledge. Twenty-one oral health questions were asked to assess oral health knowledge using a score based on their answers to questions such as do you think dental plaque is the main cause of periodontitis or do you think oral diseases can cause other diseases such as diabetes mellitus or cardiovascular disease? In addition, information on smoking status and alcohol drinking status was also collected using the same questionnaire.

Statistical analysis

SPSS statistical package (Version 12.0, SPSS Inc., Chicago, IL, USA) was used for the data analysis. An independent-sample *t*-test, and χ^2-test were used to compare the baseline characteristics and periodontal status between cases and controls for continuous variables and categorical variables, respectively. Logistic regression was performed to calculate the odds ratio (OR) and 95% confidence interval (CI) for evaluating the associations of periodontal health status and oral health behaviours with the risk of COPD. In the multivariate-adjusted models, we included age, gender, and body mass index (BMI) to control for potential confounding. Because smoking could be an important effect modifier for the relation of periodontal disease and COPD (Hyman & Reid 2004), our logistic regression analyses were stratified by smoking status (non-smoker, former smoker, and current smoker).

Results

Demographics

The basic demographic characteristics of the study population are presented in Table 1. The mean age of the COPD group was 63.94 ± 9.84 years; 68.6%

were males and 31.4% were females. The mean age of the control group was 63.26 ± 8.98 years; 50.0% were males and 50.0% were females. Compared with the controls, COPD patients had a greater proportion of former and current smokers ($p < 0.0001$). There was no difference in the mean BMI of patients (24.97 ± 3.83) and controls (25.32 ± 3.73) ($p = 0.242$).

Periodontal health status and COPD

COPD patients had fewer remaining teeth (21.54 ± 6.27 *versus* 23.07 ± 5.63) ($p = 0.001$), a higher PLI (2.61 ± 0.53 *versus* 2.41 ± 0.94) ($p = 0.001$), and had more site percentages of CAL (CAL ⩾ 4 mm site: $p = 0.011$; CAL ⩾ 3 mm site: $p = 0.033$) than the controls with normal pulmonary function (Table 2). There was no significant difference in other periodontal indexes (PD, BI, and alveolar bone loss) between COPD cases and controls. After adjusting for age, gender, and BMI and stratifying by smoking status in the logistic regression models, the number of remaining teeth ($p = 0.045$) among non-smokers and PLI ($p = 0.044$) among current smokers were also significantly associated with COPD (Table 3). In particular, the adjusted OR of COPD for each unit increase in PLI was 2.34 (95% CI, 1.03–5.34) among current smokers.

Univariate analysis of oral health behaviour condition with COPD

There were low correlations between any two of the oral health covariates (all Pearson's correlation coefficients < 0.17). Compared with the control group, the group of COPD patients had lower tooth brushing times ($p < 0.0001$) and oral health knowledge scores ($p < 0.0001$) (Table 4). Also, patients had a higher proportion of the use of the horizontal tooth brushing method (51.2% *versus* 36.1%, $p < 0.0001$), a lower proportion of the vertical tooth brushing method (44.2% *versus* 57.2%; $p = 0.004$), and a lower proportion of dental floss use (4.5% *versus* 11.4%; $p = 0.002$) than those without COPD. COPD patients were less likely to have dental visits (42.0% *versus* 59.3%; $p < 0.0001$) and receive regular supra-gingival scaling treatment (25.2% *versus* 45.8%; $p < 0.0001$).

Multivariate-adjusted analyses of oral health behaviour condition with COPD

To minimize a potential confounding effect, we adjusted for the variables of age, gender, and BMI in logistic regression models. We also treated smoking status as an important effect modifier and stratified it in the logistic regression analyses (Table 5). When these oral health behaviour variables were adjusted simultaneously, the horizontal tooth brushing method was significantly associated with COPD only among non-smokers ($p = 0.025$), while lower regular supra-gingival scaling retained statistically significant associations with COPD among non-smokers ($p = 0.027$) and among former smokers ($p < 0.0001$). In particular, the adjusted OR of lower regular supra-gingival scaling among former smokers was 3.77 (95% CI, 1.82–7.81). Poor oral health knowledge was significantly associated with COPD in all subgroups ($p < 0.0001$ among non-smokers, $p = 0.019$ among former smokers, and $p = 0.044$ among current smokers); the adjusted OR of poorer oral health knowledge was 2.85 (95% CI, 1.70–4.76) among non-smokers, 2.41 (95% CI, 1.16–5.04) among former smokers, and 2.69 (95% CI, 1.03–7.02) among current smokers.

Table 1. Basic characteristics of the study population

Characteristic	COPD group ($n = 306$)	Control group ($n = 328$)	p-value*
Mean ± standard deviation			
Age	63.94 ± 9.84	63.26 ± 8.98	0.366
Body mass index (BMI)	24.97 ± 3.83	25.32 ± 3.73	0.242
Distribution of subjects (%)			
Gender			< 0.0001
Male	210 (68.6)	164 (50.0)	
Female	96 (31.4)	164 (50.0)	
Smoking status			< 0.0001
Non-smoker	105 (34.3)	231 (70.4)	
Former smoker	154 (50.3)	56 (17.1)	
Current smoker	47 (15.4)	41 (12.5)	
Marriage status			0.503
Single	25 (8.2)	26 (7.9)	
Married	281 (91.8)	302 (92.1)	
Living status			0.176
Living alone	19 (6.2)	14 (4.3)	
Living with family	287 (93.8)	314 (95.7)	

*p-value obtained from Student's t-test for continuous variables and χ^2-test for categorical variables.

Table 2. Univariate analysis of periodontal health in COPD and control groups

Clinical parameter (Mean ± standard deviation)	COPD group ($n = 306$)	Control group ($n = 328$)	p-value†
Periodontal index			
Number of remaining teeth	21.54 ± 6.27	23.07 ± 5.63	0.001*
PD	3.12 ± 0.72	3.20 ± 0.76	0.146
CAL	4.79 ± 1.60	4.54 ± 1.73	0.059
BI	2.21 ± 0.63	2.31 ± 0.77	0.075
PLI	2.61 ± 0.53	2.41 ± 0.94	0.001*
Alveolar bone loss	1.49 ± 0.46	1.43 ± 0.44	0.067
Moderate and severe site percentages			
PD ⩾ 4 mm site percentages	30.24 ± 13.18	33.17 ± 14.08	0.109
CAL ⩾ 3 mm site percentages	84.81 ± 20.20	80.82 ± 26.06	0.033*
PD ⩾ 5 mm site percentages	12.47 ± 4.30	14.75 ± 5.19	0.061
CAL ⩾ 4 mm site percentages	70.12 ± 18.87	64.00 ± 21.36	0.011*

*$p < 0.05$ statistically significant.
†p-value obtained from Student's t-test.
PD, probing depth; CAL, clinical attachment level; BI, bleeding index; PLI, plaque index.

Discussion

In this study, COPD patients appeared to have a poorer periodontal health status than controls with normal pulmonary function. Specifically, COPD patients had fewer remaining teeth, a higher PLI, and greater CAL site percentages than the controls. Our study also showed

Table 3. Adjusted ORs and 95% CIs of COPD in relation to periodontal health stratified by cigarette smoking status

Smoking status	Clinical parameter	*p*-value*	OR	95% CI
Non-smoker	Number of remaining teeth	0.045*	1.05	1.01–1.11
	PLI	0.302	1.17	0.87–1.59
	CAL ⩾ 3 mm site percentages	0.933	1.00	0.99–1.01
	CAL ⩾ 4 mm site percentages	0.901	1.00	0.99–1.01
Former smoker	Number of remaining teeth	0.573	1.02	0.96–1.07
	PLI	0.356	1.33	0.73–2.45
	CAL ⩾ 3 mm site percentages	0.754	1.00	0.99–1.02
	CAL ⩾ 4 mm site percentages	0.812	0.99	0.99–1.01
Current smoker	Number of remaining teeth	0.162	1.06	0.98–1.14
	PLI	0.044*	2.34	1.03–5.34
	CAL ⩾ 3 mm site percentages	0.870	0.99	0.97–1.02
	CAL ⩾ 4 mm site percentages	0.873	1.00	0.98–1.02

*$p < 0.05$ statistically significant.
The logistic regression analyses were stratified by smoking status and adjusted for age, gender, and body mass index.
OR, odds ratio; CI, confidence interval; PLI, plaque index; CAL, Clinical attachment level.

Table 4. Univariate analysis of oral health behaviours in COPD and control groups

Oral health behaviours	COPD group	Control group	*p*-value*
Distribution of subjects (%)			
Tooth brushing times			< 0.0001
⩽ 1 time/day	47.9	31.9	
⩾ 2 times/day	52.1	68.1	
Horizontal tooth brushing method			< 0.0001
Yes	51.2	36.1	
No	48.8	63.9	
Vertical tooth brushing method			0.004
Yes	44.2	57.2	
No	55.8	42.8	
Using dental floss			0.002
Yes	4.5	11.4	
No	95.5	88.6	
Dental visit in last year			< 0.0001
Yes	42.0	59.3	
No	58.0	40.7	
Have regular supra-gingival scaling			< 0.0001
Yes	25.2	45.8	
No	74.8	54.2	
Mean ± Standard deviation			
Oral health knowledge score	71.2 ± 17.8	80.6 ± 12.9	< 0.0001

*p-value obtained from χ^2-test for categorical variables and Student's t-test for continuous variables.

Table 5. Adjusted ORs and 95% CIs of COPD in relation to oral health behaviours

Smoking status	Oral health behaviour states	*p*-value	OR	95% CI
Non-smoker	Horizontal tooth brushing method: Yes *versus* No	0.025*	1.65	1.07–2.56
	Regular supra-gingival scaling: No *versus* Yes	0.027*	1.81	1.07–3.04
	Oral health knowledge: low *versus* High	< 0.0001*	2.85	1.70–4.76
Former smoker	Horizontal tooth brushing method: Yes *versus* No	0.306	1.45	0.71–2.93
	Regular supra-gingival scaling: No *versus* Yes	< 0.0001*	3.77	1.82–7.81
	Oral health knowledge: low *versus* High	0.019*	2.41	1.16–5.04
Current smoker	Horizontal tooth brushing method: Yes *versus* No	0.185	1.80	0.76–4.26
	Regular supra-gingival scaling: No *versus* Yes	0.265	1.71	0.67–4.40
	Oral health knowledge: low *versus* High	0.044*	2.69	1.03–7.02

*$p < 0.05$ statistically significant.
The logistic regression analyses were stratified by smoking status and adjusted for age, gender, and body mass index.
OR, odds ratio; CI, confidence interval.

that inappropriate oral health behaviours including inappropriate tooth brushing method, lower regular supra-gingival scaling, and poorer oral health knowledge were significantly associated with an increased risk of COPD. These findings indicate the importance of promoting dental care and oral health knowledge in the prevention and treatment of COPD.

To the best of our knowledge, there are very limited data on the importance of oral health in the medical care of COPD patients. Our case–control study provided the first comprehensive analysis of oral health and behaviours in relation to COPD. The observed association between periodontal health status and COPD was consistent with previous studies (Scannapieco & Ho 2001, Katancik et al. 2005). Katancik et al. (2005) studied 860 elderly patients and found that the CAL was significantly higher in COPD patients than in participants with normal pulmonary function. Specifically, among former smokers, all periodontal measures including PLI and CAL were associated with pulmonary disease status. Another cross-sectional epidemiological study suggested that current smokers with ⩾ 4 mm CAL had a high risk of COPD (OR: 3.71) (Hyman & Reid 2004). We also found that current smokers with higher PLI had a high risk of COPD (OR: 2.34). The results of these studies support an association between poor periodontal health status and COPD. A high PLI and moderate and severe CAL may be risk factors for the development of COPD. The pathogenic mechanisms linking periodontal health to COPD are not entirely understood, but chronic inflammatory processes are likely to be involved. Periodontitis is a chronic inflammatory reaction from which oral pathogens and inflammatory cytokines may induce systemic inflammation, which has been implicated in the pathogenesis of COPD (Terpenning 2001).

Although several studies have observed the association between periodontal health status and COPD, this is the first study to evaluate the association between oral health behaviours and COPD. Health-related knowledge, attitudes, and beliefs have been found to influence one's oral health behaviour and oral health. Our study showed relatively low correlations between any two of the oral health behaviour variables (all $r^2 < 0.17$), indicating that they may independently reflect different aspects

of overall oral health. Because smoking is a major risk factor for both periodontal disease and a number of other diseases including COPD, smoking should be identified as an effect modifier (Hyman 2006, Ylöstalo & Knuuttila 2006). To address the interaction among cigarette smoking status, periodontal disease, and COPD, the logistic regression analyses were stratified by smoking status. Gender and other variables were also adjusted in the regression model. The horizontal tooth brushing method was defined as an inappropriate method because it could cause wedged cervical lesions and may not be as efficient as the vertical tooth brushing method or the short horizontal strokes method (Miyazaki et al. 1990, Litonjua et al. 2004, Gonçalves et al. 2007). After accounting for potential confounding effects by age, sex, BMI, and stratified by cigarette smoking status, our study also showed that self-assessed poor oral health behaviour including inappropriate tooth brushing method and low regular periodontal health care were significantly associated with an increased risk of COPD among non-smokers while low regular periodontal health care remained associated with COPD among former smokers. Poorer oral health knowledge appeared to be associated with COPD among all three subgroups stratified by smoking status (non-smokers, former smokers, and current smokers). Inappropriate tooth brushing could not effectively remove the bacteria plaque, and so we found a high PLI in the COPD group. Thus, bacteria associated with the pulmonary infection are more likely to congregate and multiply in the oral cavity. Altogether, these findings indicate the importance of oral health-related education as a key element in the improvement and maintenance of oral health and hygiene of COPD patients.

This is the first study to evaluate the association between oral health and COPD in a Chinese population. Our findings have important public health and clinical implications for the prevention and treatment of both conditions. Nonetheless, several limitations of the present study merit consideration. First, our case–control study was retrospective and thus our findings do not necessarily reflect a causal effect. Future interventional studies are required to assess the efficacy of oral health care in the development and progression of COPD. In addition, we may not have enough power for our subgroup analyses stratified by smoking status because of the relatively small sample sizes in current smokers. Furthermore, the prevalence of COPD is higher in smokers and ex-smokers than in non-smokers, and so inadequate power in our subgroups might have contributed to some negative results. Also, oral health status may be a surrogate for general health status. We cannot completely exclude the possibility of residual confounding and effect modification by other healthy lifestyle variables; it seems unlikely that such confounding or effect modification could largely account for our significant findings because our multivariate-adjusted models controlled for important risk factors for COPD including cigarette smoking. In addition, imprecise measures of oral health behaviour-related variables could have attenuated the observed associations.

In conclusion, our case–control study showed that, in addition to smoking, poor periodontal health, dental care, and oral health knowledge were significantly associated with an increased risk of COPD. Promoting oral health knowledge, generalizing the appropriate tooth brushing method, and clinical periodontal health care in COPD patients may help to prevent the progression of COPD. Although the evidence is indirect, our results lend support to the importance of oral health care and education in the management of the care of patients with COPD. Such research may ultimately stimulate future prospective cohort studies or clinical trials that are needed to understand the causal effect of periodontal health care on COPD and the potential effect of promoting oral health knowledge and improving periodontal health in the management of the care of patients with COPD.

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Clinical Relevance

Scientific rationale for study: The associations of periodontal health status and oral health behaviours with COPD are unclear due to the lack of population data.

Principal findings: Higher PLI, inappropriate tooth brushing method, lower supra-gingival scaling, and poorer oral health knowledge were significantly associated with the risk of COPD.

Practical implications: Promoting oral health knowledge, appropriate tooth brushing method, and regular supra-gingival scaling may be important to be integrated into the prevention and treatment of COPD.