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# Periodontal health and quality of life in patients with chronic obstructive pulmonary disease

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Quality of life

**Summary**
*Objective:* To evaluate the association of periodontal health and parameters of quality of life assessed in 306 Chinese patients with chronic obstructive pulmonary disease (COPD).
*Methods:* Periodontal status and respiratory function in 306 COPD patients were clinically evaluated and their quality of life was assessed using the standardized St George's Respiratory Questionnaire (SGRQ).
*Results:* The SGRQ scores were all significantly correlated with major lung function parameters ($r^2 = -0.37$ to $-0.28$; all $p < 0.0001$) and Medical Research Council dyspnoea scale ($r^2 = 0.23$ to 0.30; all $p < 0.0001$). The SGRQ scores also correlated with the 6-min walk test ($r^2 = -0.15$ to $-0.13$; all $p < 0.05$). Of periodontal health parameters, missing tooth number and plaque index appeared to be related to the scores of quality of life. The age- and gender-adjusted Pearson's correlation coefficients between missing teeth and total score, symptoms score, and activity score were 0.09, 0.12, and 0.12, respectively (all $p < 0.05$). The Pearson's correlation coefficients between plaque index and symptoms score and activity score were 0.09 and 0.09 ($p < 0.05$). After adjusting for age, gender, body mass index, and smoking status, missing teeth remained significantly associated with symptom score ($p = 0.030$) and activity score ($p = 0.033$) while plaque index was significantly associated with symptom score ($p = 0.007$).
*Conclusions:* Poor periodontal health as reflected by missing teeth and plaque index was significantly associated with lower quality of life in COPD patients. Our findings indicate the importance of promoting dental care in current public health strategies to improve the quality of life in COPD patients.


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## Introduction

Chronic obstructive pulmonary disease (COPD) has evolved as one of the major global causes of death and disability over the past decades.[1] Due to the alarming increase in COPD prevalence, COPD has become a major public health burden worldwide. It was predicted that COPD will become the third most common cause of death and the fourth most important disease leading to disability by the year 2020.[2–4]

COPD patients suffer from varying degrees of disability in various aspects of their daily life. Lung function parameters assessed by spirometry have been used for the past few decades to diagnose COPD, assess disease severity, or to evaluate treatment benefits in COPD patients.[5] However, measurements of lung function do not necessarily reflect patients' disability. It is well accepted that the goal of COPD therapy should not be only to improve the physiological and functional state, but also to minimize the impact of the disease on the patients' quality of life. The St George's Respiratory Questionnaire (SGRQ) was developed in 1991 by Jones et al. to measure impaired health and quality of life in chronic airway disease.[6,7] In this regard, the SGRQ consists of three specific domains: symptoms (distress due to respiratory symptoms), activity (the effects due to impairment of mobility or physical activity), and impacts (the psychosocial effect of the disease on the individual). The SGRQ has been translated into several languages[8–10] and widely used in the assessment of quality of life in COPD patients.[11–13]

COPD risk factors such as cigarette smoking and inflammation may explain some of variability in quality of life in COPD patients. There is evidence to show a possible association between periodontitis and COPD in recent years. Didilescu et al. indicated that dental plaque in patients with chronic lung diseases often serves as a reservoir of bacteria known to cause nosocomial pneumonia.[14] In a systematic review of nineteen papers addressing a possible association between respiratory disease and oral health,[15] four of them specifically examined the relation of oral health indicators and COPD.[16–19] The evidence from these four cross-sectional studies suggested an association between poor oral health (including alveolar bone loss, periodontal attachment loss, oral hygiene index, and oral plaque colonization) and chronic pulmonary disease. Recently, two case-control studies also found that poor periodontal health including alveolar bone loss, and dental care were significantly associated with increased risk of COPD.[20,21] However, it remains unclear whether and to what extent periodontal health would impact on the quality of life in COPD patients due to the lack of data. Such information could be very useful for the development and improvement of effective early prevention or treatment for COPD patients. Therefore, we conducted a population study to examine the association of periodontal health and the quality of life as assessed by the St George's Respiratory Questionnaire in 306 Chinese COPD patients.

## Materials and methods

### Study population

In total, 306 patients with COPD were recruited from Beijing ChaoYang hospital and other seven hospitals in Beijing from March 2007 to November 2008. Consecutive patients were based on the following eligibility criteria: 1) aged $\geq$30 years with more than 15 teeth; 2) physician-diagnosed COPD, post-bronchodilator forced expiratory volume in 1 second/forced vital capacity ($FEV_1$/FVC) ratio $<$0.7 and $FEV_1<80\%$ of predicted value; 3) no fever, no worsening of respiratory symptoms and no medication change within 4 weeks prior to baseline interview; 4) no primary diagnosis of asthma; 5) no previous lung volume reduction surgery, lung transplantation or pneumonectomy; and 6) expected survival of at least 6 months. To ensure the compliance with our standardized protocol at each site of all the involved hospital, the doctors and interviewers of Beijing ChaoYang hospital went to other seven hospitals to be responsible for the recruitment of COPD patients. Basic demographic variables such as age, gender, lifestyle, smoking status and alcohol drinking status were collected by trained interviewers, and anthropometric variables including height, weight, and blood pressure were measured by nurses.

The Human Research Ethnical Board from Beijing ChaoYang hospital approved the study, and written informed consent was obtained from all participants.

### Diagnosis of COPD and assessment of lung function by spirometry and other respiratory tests

Criteria used for the diagnosis of COPD and classification of severity were based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometry guidelines: Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease (Update 2007).[5]

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 had similar results for forced expiratory volume (FEV) in one second ($FEV_1$) and forced vital capacity (FVC). The pulmonary evaluation based on the $FEV_1$/FVC and then using the percent of predicted $FEV_1$ to categorize severity. Air limitation was defined using the fixed ratio post-bronchodilator $FEV_1$/FVC $<$0.70. Mild limitation was defined as a predicted $FEV_1$ between 80% and 100%; moderate as a predicted $FEV_1$ between 50% and 80%; severe as a predicted $FEV_1$ between 30% and 50%; and very severe as a predicted $FEV_1$ below 30% predicted or $FEV_1$ below 50% predicted plus the presence of chronic respiratory failure.

The 6-min walk test (6MWT) was used as a field test to assess the patients' exercise capacity following the American Thoracic Society guideline.[22] The test was performed twice and the best performance was used for analysis. The patients also completed the Medical Research Council (MRC) dyspnoea scale for grading the degree of a patient's breathlessness.[23]

### Assessment of life of quality using SGRQ

The SGRQ was composed of three dimensions: symptoms, specific respiratory symptoms; activity, a measure of the activities that cause or are limited by breathlessness; and

impact, a measure of the overall disturbance of daily life, social function, and well-being.[7] A score was calculated for each section and a total summary score was also calculated. The scoring range was 0—100. A high score indicated poor health and a decrease in the score indicates an improvement in quality of life. Mandarin-Chinese version of the questionnaire has been demonstrated to be a reliable and valid instrument for quality of life evaluation in COPD patients in China.[10,24] Replicate measurements were conducted after one week of the first measurements. The repeatability of the questionnaire was also high. The test-retest intra-class correlation coefficient of total, symptoms, activity, and impacts scores were 0.89, 0.82, 0.89, and 0.85, respectively.[10]

### Periodontal examination

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 and intra-examiner reliability was assessed. The *Kappa* value of agreement was 0.82. The evaluation included periodontal probing, oral hygiene, number of missing teeth, 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 millimeters. Recession was recorded as a positive value if the free gingival margin occurred apical to the cemento-enamel junction, whereas it was recoded as a negative value if it was coronal to the CEJ. CAL was calculated using the formula PD + CEJ = CAL. Bleeding index (BI) on probing was scored on a 0 to 5 scale when any visual evidence of bleeding was noted.[25] Plaque index (PLI) for each tooth was determined on a 0 to 3 scale after air drying.[26] Alveolar bone loss was examined by 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 root in length; 2 = alveolar bone loss between 1/3 and 2/3 of root in length; and 3 = alveolar bone loss more than 2/3 of root in length. Dental caries and oral mucosal were also been evaluated.

### Statistical analysis

SPSS statistical package (Version 12.0, SPSS Inc., Chicago, IL, USA) was used for the data analysis. Basic characteristics and SGRQ scores among different COPD stages were compared using one-way ANOVA for continuous variables and $\chi^2$ test for categorical variables. Pearson's correlation coefficients were calculated to assess the correlations of the SGRQ scores with respiratory system measures and periodontal indexes. To control for possible confounding effects, linear regression analysis was performed to calculate the SGRQ scores in relation to periodontal indexes. In the multivariate-adjusted models, we included age, gender, body mass index (BMI), and smoking status as covariates.

## Results

### Basic characteristics of the patients and their SGRQ scores

The basic characteristics of the 306 COPD patients including their SGRQ scores are presented in Table 1. We identified 34 mild COPD (Stage I), 146 moderate COPD (Stage II), 98 severe COPD (Stage III), and 28 very severe COPD patients (Stage IV). The mean age (±SD) of the COPD Stage I to IV were 65.6 ± 8.62 years, 64.4 ± 10.3 years, 63.1 ± 9.24 years, and 62.3 ± 11.0 years, respectively. The proportions of men were 52.9%, 69.2%, 70.4%, and 78.6%, respectively. As expected, the advanced COPD stages were significantly associated with lower $FEV_1$% of predicted, $FEV_1$/FVC, and 6MWT. The mean predicted $FEV_1$% of the COPD stage I to IV were 91.0 ± 10.5, 63.7 ± 9.61, 41.3 ± 5.40, and 24.1 ± 5.71, respectively ($p < 0.0001$). The mean 6MWT were 429 ± 70.4, 443 ± 97.9, 418 ± 98.2, and 377 ± 82.5, respectively ($p = 0.01$). The advanced COPD stages were also associated with higher MRC dyspnoea scale and SGRQ scores (total score, symptoms score, activity score, and impacts score). The mean MRC dyspnoea scale were 1.82 ± 0.46, 2.38 ± 0.65, 2.60 ± 0.78, and 3.25 ± 1.11 ($p < 0.0001$). The mean total SGRQ scores were 31.9 ± 7.03, 38.9 ± 9.83, 48.7 ± 12.6, and 55.9 ± 15.8 ($p < 0.0001$).

### SGRQ scores and respiratory system measures

The Pearson's correlation coefficients between the SGRQ scores and respiratory measures are presented in Table 2. The SGRQ scores were negatively associated with $FEV_1$% of predicted, $FEV_1$/FVC, and positively associated with MRC dyspnoea scale; their Pearson's correlation coefficients were from −0.37 to −0.32, from −0.33 to −0.28, and from 0.23 to 0.30, respectively (all $p < 0.0001$). The SGRQ scores and 6MWT were also correlated (Pearson's correlation coefficient from −0.15 to −0.09; $p < 0.05$).

### Periodontal indexes and SGRQ scores

Age- and gender-adjusted Pearson's correlation coefficients between periodontal indexes and the SGRQ scores are presented in Table 3. Missing teeth was positively associated with total scare, symptoms score, and activity score; their Pearson's correlation coefficients were 0.09, 0.12, and 0.12, respectively ($p < 0.05$). Plaque index was also positively associated with symptoms score and activity score, the Pearson's correlation coefficients were 0.09 and 0.09 ($p < 0.05$).

### Linear regression analysis of SGRQ scores in relation to periodontal indexes

We used the linear regression to analyze the SGRQ scores in relation to periodontal indexes (Table 4). In the crude model, missing teeth was significantly associated with total scores ($p = 0.037$), symptoms score ($p = 0.013$) and activity score ($p < 0.0001$); plaque index was significantly

**Table 1** Basic characteristics of 306 COPD patients and their SGRQ scores in the study.

| Characteristic | COPD Stage | | | | |
|---|---|---|---|---|---|
| | I: Mild ($n = 34$) | II: Moderate ($n = 146$) | III: Severe ($n = 98$) | IV: Very severe ($n = 28$) | $p$ value* |
| Distribution of subject (%) | | | | | |
| Gender | | | | | 0.15 |
| Men | 18 (52.9) | 101 (69.2) | 69 (70.4) | 22 (78.6) | |
| Women | 16 (47.1) | 45 (37.8) | 29 (29.6) | 6 (21.4) | |
| Smoking status | | | | | 0.06 |
| Non-smoker | 18 (52.9) | 52 (36.1) | 26 (26.5) | 9 (32.1) | |
| Former smoker | 12 (35.3) | 65 (45.1) | 59 (60.2) | 17 (60.7) | |
| Current smoker | 4 (11.8) | 27 (18.8) | 13 (13.3) | 2 (7.10) | |
| Mean ± standard deviation (SD) | | | | | |
| Age | 65.5 ± 8.62 | 64.4 ± 10.2 | 63.1± 9.24 | 62.3 ± 11.0 | 0.43 |
| BMI | 25.8 ± 3.90 | 25.2 ± 3.15 | 24.0 ± 3.53 | 25.5 ± 6.70 | 0.03 |
| $FEV_1$% of predicted | 91.0 ± 10.5 | 63.7 ± 9.61 | 41.3 ± 5.40 | 24.1 ± 5.71 | <0.0001 |
| $FEV_1$/FVC | 68.0 ± 4.38 | 58.7 ± 9.50 | 46.4 ± 8.34 | 40.0 ± 9.60 | <0.0001 |
| 6MWT | 429 ± 70.4 | 443 ± 97.9 | 418 ± 98.2 | 377 ± 82.5 | 0.01 |
| MRC dyspnoea scale | 1.82 ± 0.46 | 2.38 ± 0.65 | 2.60 ± 0.78 | 3.25 ± 1.11 | <0.0001 |
| SGRQ scores | | | | | |
| Total | 31.9 ± 7.03 | 38.9 ± 9.83 | 48.7 ± 12.6 | 55.9 ± 15.8 | <0.0001 |
| Symptoms | 45.8 ± 10.1 | 55.9 ± 14.2 | 65.1 ± 19.3 | 70.5 ± 14.1 | <0.0001 |
| Activity | 36.5 ± 9.01 | 45.5 ± 11.2 | 54.7 ± 13.1 | 64.9 ± 17.7 | <0.0001 |
| Impacts | 21.2 ± 7.57 | 29.8 ± 7.98 | 39.7 ± 7.46 | 46.0 ± 10.7 | <0.0001 |

*: $p$ value obtained from one-way ANOVA for continuous variables and $\chi 2$ test for categorical variables.
BMI: body mass index; $FEV_1$: forced expiratory volume in one second; FVC: forced vital capacity; 6MWT: 6-min walk test; MRC: Medical Research Council; SGRQ: St George's Respiratory Questionnaire.

associated with total score ($p = 0.024$), symptom score ($p = 0.001$) and activity score ($p = 0.018$); alveolar bone loss was significantly associated with symptoms score ($p = 0.038$). To minimize potential confounding effect, we adjusted for age, gender, body mass index, and smoking status in the linear regression models. When these variables were adjusted, missing teeth was significantly associated with symptom score ($p = 0.030$) and activity score ($p = 0.033$) and plaque index was significantly associated with symptom score ($p = 0.007$).

## Discussion

In this cross-sectional study of 306 COPD patients, we found an association between poor periodontal health and low quality of life in COPD patients. Our results showed positive correlations between missing teeth with the quality of life of COPD patients, as quantified using the SGRQ total score, symptoms score, and activity score. Plaque index was also related with symptoms score and activity score in patients. Our findings provided new information to support the importance of periodontal health in the healthcare of COPD patients.

SGRQ is a specific questionnaire most commonly used in respiratory diseases. Compared to spirometry, it is a very simple method that only needs an examiner and 30 minutes to evaluate the quality of life of COPD. It could be widely used in the assessment of overall health status in COPD patients. Consistent with previous studies,[6,27] our study showed that severe COPD patients had higher SGRQ scores.

**Table 2** Pearson's correlation coefficients between SGRQ scores and respiratory system measures.

| Respiratory variable | SGRQ scores | | | |
|---|---|---|---|---|
| | Total | Symptoms | Activity | Impacts |
| $FEV_1$% of predicted | −0.37** | −0.36** | −0.32** | −0.32** |
| $FEV_1$/FVC | −0.33** | −0.31** | −0.29** | −0.28** |
| 6MWT | −0.15* | −0.09 | −0.15* | −0.13* |
| MRC dyspnoea scale | 0.29** | 0.30** | 0.26** | 0.23** |
| Age | −0.07 | −0.05 | 0.04 | −0.12* |
| BMI | 0.007 | 0.05 | −0.003 | −0.009 |

**: $p < 0.0001$ statistically significant.
*: $p < 0.05$ statistically significant.
SGRQ: St George's Respiratory Questionnaire; $FEV_1$: forced expiratory volume in one second; FVC: forced vital capacity; 6MWT: 6-min walk test; MRC: Medical Research Council; BMI: body mass index.

**Table 3** Adjusted Pearson's correlation coefficients between SGRQ scores and periodontal indexes.

| Periodontal index | SGRQ scores | | | |
|---|---|---|---|---|
| | Total | Symptoms | Activity | Impacts |
| Missing teeth | 0.09* | 0.12* | 0.12* | 0.05 |
| PD | 0.06 | 0.05 | 0.02 | 0.07 |
| CAL | 0.03 | 0.009 | 0.008 | −0.06 |
| BI | 0.05 | 0.05 | 0.03 | 0.03 |
| PLI | 0.07 | 0.09* | 0.09* | 0.03 |
| Alveolar bone loss | 0.02 | 0.07 | 0.04 | −0.02 |

*: $p < 0.05$ statistically significant.
The correlations were adjusted for age and gender.
SGRQ: St George's Respiratory Questionnaire; PD: probing depth; CAL: clinical attachment lever; BI: bleeding index; PLI: plaque index.

There were significant correlations between the SGRQ scores and $FEV_1$% of predicted, $FEV_1$/FVC, and MRC dyspnoea scale. SGRQ score and 6MWT also had week correlations. These findings indicated the validity of using SGRQ scores to evaluate the quality of life of COPD patients based on the severity of lung function.

Although several studies have observed the association between periodontal health status and COPD, to our knowledge, this is the first study to evaluate the association between periodontal health and quality of life in COPD patients. We found positive correlations between missing teeth and all SGRQ scores except for impacts score and correlations between plaque index with symptoms score and activity score. These findings are consistent with the previous studies about the association between periodontal health and COPD.[16,17,28] Scannapieco et al. analyzed the dada from the National Health and Nutrition Examination Survey I and found individuals with a confirmed chronic respiratory disease had significantly greater oral hygiene index (OHI) scores than normal subjects. Subjects having the maximum OHI value were 4.5 times more likely to have a chronic respiratory disease than those with an OHI of 0. Katancik et al. studied 860 elderly patients and found among former smokers, all periodontal measures including plaque index and CAL were associated with pulmonary disease status.[29] Results of these studies support an association between poor periodontal health status and COPD. In the adjusted linear regression model, we also found missing teeth was significantly associated with symptom score and activity score. In addition, plaque index was significantly associated with symptom score. Our study found an association between poor periodontal health status and lower quality of life as reflected as higher SGRQ scores in COPD patients. These results suggest that a high plaque index and severe missing teeth may be periodontal indicators in reflecting the lower quality of life in COPD patients.

Although the precise mechanisms are unknown, there are several potential explanations for an association between poor periodontal health status and the severity of COPD. Periodontitis may be linked to COPD through microbial species, either by supporting colonization of respiratory pathogens in dental plaque,[21] or by periodontal pathogens and their products that can promote airway inflammation and exacerbations. Brook's study found elevated antibody levels against *Fusobacterium nucleatum* and *Prevotella intermedia*, two important periodontal pathogens, in the sputum of patients with an acute exacerbation of chronic bronchitis.[30] Pavord et al. suggested that the coexistence of multiple inflammatory stimuli to the airway maybe a key factor leading to the development of more severe airway disease.[31] A large number of inflammatory factors are released continuously from periodontal lesions and peripheral mononuclear cells and thus induce a more severe inflammatory response. Periodontal inflammatory stimulus may cause more severe symptoms of COPD that subsequently could result in higher SGRQ scores indicating poor quality of life in COPD patients.

**Table 4** Linear regression analysis of SGRQ scores in relation to periodontal indexes.

| Periodontal index | *p* values of SGRQ scores | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | | Symptoms | | Activity | | Impacts | |
| | Crude | Adjusted | Crude | Adjusted | Crude | Adjusted | Crude | Adjusted |
| Missing teeth | 0.037* | 0.16 | 0.013* | 0.030* | <0.0001* | 0.033* | 0.49 | 0.61 |
| PD | 0.06 | 0.06 | 0.16 | 0.64 | 0.30 | 0.46 | 0.45 | 0.08 |
| CAL | 0.98 | 0.20 | 0.16 | 0.84 | 0.37 | 0.49 | 0.33 | 0.07 |
| BI | 0.06 | 0.08 | 0.06 | 0.06 | 0.36 | 0.43 | 0.32 | 0.15 |
| PLI | 0.024* | 0.07 | 0.001* | 0.007* | 0.018* | 0.07 | 0.13 | 0.18 |
| Alveolar bone loss | 0.59 | 0.64 | 0.038* | 0.32 | 0.13 | 0.92 | 0.53 | 0.21 |

*: $p < 0.05$ statistically significant.
The linear regression analyses were adjusted for age, gender, body mass index, and smoking status.
SGRQ: St George's Respiratory Questionnaire; PD: probing depth; CAL: clinical attachment lever; BI: bleeding index; PLI: plaque index.

Because this is a retrospective study, we cannot draw any conclusion regarding a cause-and-effect association. This can be considered a limitation of the present study. Future interventional studies are required to assess the efficacy of oral health care on the improvement in quality of life of COPD patients. Also, oral health status may be a surrogate for general health status. We cannot completely exclude the possibility of residual confounding by other healthy lifestyle variables. However, it seems unlikely that such confounding effects could largely account for our significant findings because our multivariate-adjusted models controlled for important risk factors for periodontitis and COPD including cigarette smoking. In addition, there is a concern about potential confounding effects by oral health behavior factors on our observations. As discussed previously,[21] oral health behavior factors were significantly correlated with periodontal indexes. However, if these factors are causally associated with systemic diseases such as COPD, the most possible intermediate pathway are periodontal conditions. To minimize possible false negative results due to overadjustment, we didn't control the oral behavioral factors that are determinants of the periodontal indexes in the regression analysis. We believe that further investigations with longitudinal data are required to address the relation of oral behavior factors and periodontal health.

In conclusion, our study showed that poor periodontal health as reflected by more missing teeth and high plaque index was significantly associated with lower quality of life in COPD patients. Our findings suggest that promoting periodontal health care in COPD patients may be important for improving their quality of life and preventing the progression of COPD.

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## Conflict of interest and source of funding statement

The authors declare no conflict of interests related to this study.

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The Human Research Ethnical Board from Beijing ChaoYang hospital approved the study; written informed consent was obtained from all participants.

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