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Association between oral health status and chronic obstructive pulmonary disease in Korean adults

Eun Seo Jung, Kyeong Hee Lee and Yoon Young Choi

Department of Dental Hygiene, College of Bioecological Health, Shinhan University, Uijeongbu, Korea.

Objectives: This study aimed to elucidate the association between oral health status and chronic obstructive pulmonary disease (COPD) in Korean adults (≥ 40 years old) using a representative national dataset from the 6th Korea National Health and Nutrition Examination Survey (6th KNHANES, 2013–2015). **Methods:** Participants aged ≥ 40 years from the 6th KNHANES who had received an oral and pulmonary function tests (N = 7719) were included in this study. The participant characteristics according to COPD were compared using t-test and chi-squared test. Logistic regression analysis was used to estimate the association between oral health status and COPD. **Results:** Participants with poor periodontal status exhibited a higher prevalence of COPD. Moreover, patients with COPD had a greater number of missing teeth than those without COPD. The logistic regression model adjusted for demographic, socioeconomic, health- and oral health-related factors showed that the periodontal status was not significantly associated with COPD, while participants with more missing teeth had a significantly increased possibility of having COPD. **Conclusions:** This study revealed that loss of teeth in adults aged ≥ 40 years was associated with COPD.

Key words: *Chronic obstructive pulmonary disease, Korea National Health and Nutrition Examination Survey (KNHANES), tooth loss, oral health, periodontal disease*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterised by chronic inflammation of the bronchial tubes causing damage to the trachea and lung parenchyma and, consequently, a reduction in airflow[1]. Airflow is defined as the ratio of forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) by pulmonary function test (PFT), and is less than 70% in patients with COPD[2]. COPD symptoms include chronic cough, expectoration, dyspnoea, worsening of pulmonary function, and eventually death[3].

Chronic obstructive pulmonary disease was ranked the seventh most common cause of mortality in 2015, and is expected to become third by 2020 in the Republic of Korea. It is also the fifth most common cause of mortality in older Korean individuals[3,4]. Furthermore, according to an analysis by the World Health Organization, COPD was ranked fourth and third among the top 10 mortality-causing diseases, in 2004 and 2016, respectively[5]. With increasing prevalence and mortality, the socioeconomic burden and medical expenses associated with COPD are also expected to increase[6], both directly (i.e. diagnosis and treatment) and indirectly (i.e. economic loss from respiratory disorders and premature death)[7,8].

Chronic periodontal disease is characterised by loss of periodontal soft tissue and alveolar bone. It is the most common cause of tooth loss in Korean individuals and, thus, is a major oral health issue addressed in the 4th National Health Plan (2016–2020)[9]. Previous studies have reported an association between periodontal diseases and systemic conditions, such as diabetes, rheumatoid arthritis, cardiovascular disease and chronic respiratory diseases[10–12].

The association between COPD and periodontal disease was summarized recently[10]. Although the mechanism underlying this association remains unclear, the key pathogens and inflammatory cytokines implicated in periodontal diseases are also shared by COPD, serving as a potential common link that induces systemic inflammation[13]. Oral microbes easily invade the respiratory system via the lower trachea, and salivary enzymes associated with periodontal disease induce changes in the respiratory environment that further exacerbate pulmonary diseases[10].

Cytokines associated with periodontal diseases also induce alveolar epithelial changes and reduce defense capability against respiratory pathogens[11]. Furthermore, the medications used in COPD treatment have side-effects on the oral health of the patients. Glucocorticoids reduce oral immunity and worsen periodontal health; while salbutamol and tiotropium bromide cause hyposalivation and xerostomia[14].

Case–control and cross-sectional studies have reported the association between COPD and periodontal diseases, tooth loss, and decreased oral health status. These studies also report periodontal disease as a risk factor for COPD[15–19]. A cohort study by Barros *et al.*[19] identified tooth loss as a risk factor for COPD. Despite the growing international interest, very few studies have assessed the association between periodontal disease and COPD in the Korean population.

The present study aimed to investigate the association between oral health status and COPD in Korean adults (≥ 40 years old) using the Community Periodontal Index (CPI) and data on tooth loss from a representative national dataset of the 6th Korea National Health and Nutrition Examination Survey (6th KNHANES, 2013–2015)[20].

MATERIALS AND METHODS

Participants

The 6th KNHANES covered approximately 11,520 households across Korea, and included all family members aged ≥ 1 year between January 2013 and December 2015. It utilised a sampling frame from the most recent version of the Population and Housing Census. The sampling frames were stratified using city/provinces, dong/eup/myeon (townships in Korea), and housing types (house and apartments) as standards. A stratified two-stage cluster sampling was employed for sample extraction, with districts and families as the primary and secondary sampling units, respectively. The proportion of living space and householder's educational status were used as implicit stratification standards.

Data used in the present study were collected and used with the approval of the Institutional Review Board of the Korea Center for Disease Control and per the World Medical Association Declaration of Helsinki. Informed written consent was obtained from all study participants before survey enrollment.

Study tools

Health examination survey

Of the 22,948 participants in the 6th KNHANES (2013–2015), 7,719 adults aged ≥ 40 years who had undergone an oral examination and PFTs were included in this study. Participants' sex, age, educational level, household income, smoking status and alcohol consumption data were collected using a health examination survey and selected as confounding variables in this study. The educational level and household income were used as proxies for participants' socioeconomic status.

Participants were divided into the following groups based on educational level; ≤ elementary school level, middle school graduates, high school graduates, or ≥ university or college graduates. Based on the household income quartiles, participants were categorised into low-, middle–low-, middle–high- or high-income groups. Health-related data on smoking status (non-smoker, former smoker, or current smoker) and monthly alcohol consumption [< 1 time or ≥ 1 time(s) per month] were collected. Oral health-related factors such as daily tooth brushing (< 3 times or ≥ 3 times per day) and regular dental check-ups (Yes or No) were ascertained.

Oral health assessment

Periodontal disease was assessed using the CPI. After dividing the oral cavity into six sextants (upper posterior right, upper anterior, upper posterior left, lower posterior right, lower anterior, and lower posterior left), the periodontal status of each sextant was assessed. A CPI score of 0 indicated a healthy periodontal status, and a score of 1 indicated bleeding periodontal tissue after probing. Periodontal tissue with calculus was given a CPI score of 2, and periodontal tissue with shallow periodontal pockets (4–5 mm) and deep periodontal pockets (≥ 6 mm) were given a CPI score of 3 and 4, respectively. For convenience, KNHANES exams on the central incisor, first and second molars were selected as index teeth, and the highest score adopted as the participant's final CPI score. In the present study, the subject periodontal status was divided into CPI = 0, CPI = 1–2 and CPI = 3–4 groups based on the final CPI scores. Missing teeth were calculated from a total starting number of 28 teeth (excluding the third molars), including whole tooth loss even if functionally restored.

Pulmonary function test

The pulmonary function test involved calculating the ratio between FVC, which is the maximum amount of inhalation and exhalation at the fastest speed, and FEV_1, which is the amount of air exhaled in 1 second. In the KNHANES, PFT outcomes were classified as normal, restrictive or obstructive pattern. In the present study, these values were dichotomized as either 'no COPD' (normal or restrictive pattern, per the KNHANES) or 'COPD' (obstructive pattern).

Data analyses

Rolling survey data from the KNHANES were analysed using a complex sampling analysis method, which applies individual weights using cluster sampling of variables and variance estimates for accurate data analysis. General participant characteristics were assessed using frequency analysis. Chi-squared tests were used to compare the prevalence of COPD. Participant age and the number of missing teeth between the two groups were compared using *t*-tests. Logistic regression analyses were performed to understand the association between oral health and COPD, and odds ratio (OR) and 95% confidence interval (CI) were calculated. Bonferroni correction was performed for the multiple testing, and $P < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS statistics (version 21.0, IBM, Armonk, NY, USA).

RESULTS

The percentages of male and female participants were 50.5% and 49.5%, respectively, and the mean age of the participants was 54 years (*Table 1*).

Chronic obstructive pulmonary disease status

The prevalence of COPD in males (19.7%) was threefold greater than in females (6.0%). The mean age was noticeably higher in patients with COPD than in those without COPD ($P < 0.001$). COPD was more prevalent in the lower educational status and lower household income groups. Based on smoking history, the prevalence of COPD among current smokers (19.3%) and former smokers (19.4%) was higher than that among non-smokers ($P < 0.001$). COPD prevalence was higher in individuals who brushed their teeth < 3 times per day, and in those who did not receive a dental check-up in the past year. Based on periodontal status, individuals with CPI scores of 3–4 exhibited a greater than twofold prevalence of COPD than individuals with CPI scores of 0–2. Moreover, participants with COPD exhibited a greater number of missing teeth. However, we found no significant difference based on alcohol consumption levels (*Table 2*).

Association between oral health status and chronic obstructive pulmonary disease

The results of the logistic regression analyses performed to evaluate the association between oral health status and COPD are shown in *Table 3*. In the unadjusted model I, the possibility of COPD was higher in those with CPI scores of 1–2 (OR, 2.240; CI, 1.867–2.687) and CPI scores of 3–4 (OR, 2.985; CI, 2.368–3.762) than those with a CPI score of 0. Furthermore, participants with a greater number of missing teeth exhibited a greater chance of having COPD (OR, 2.081; CI, 1.971–2.190). After including the demographic, socioeconomic, health, and oral health factors in the logistic regression analysis, the periodontal status was not significantly associated with COPD, whereas the number of missing teeth was significantly associated with COPD (OR, 1.316; CI, 1.202–1.529; *Table 3*).

Table 1 General participant characteristics

Factors	Characteristics	Unweighted (*n*)	Weighted (%)
Demographic factors			
Sex	Male	3,242	49.5
	Female	4,477	50.5
Age, years	54.71 (0.17)†		
Socioeconomic factors			
Education level	≤ Elementary school	2,035	21.0
	Middle school	1,073	13.9
	High school	2,427	36.1
	≥ University or College	1,815	29.0
Household income	Low	1,549	16.0
	Middle–low	2,001	24.8
	Middle–high	1,908	27.1
	High	2,233	32.2
Health-related factors			
Smoking	Never smoker	4,731	56.6
	Former smoker	1,678	23.2
	Current smoker	1,205	20.2
Alcohol consumption	< 1 per month	3,899	46.1
	≥ 1 per month	3,715	53.9
Oral health-related factors			
Tooth brushing	< 3	3,817	49.7
	≥ 3	3,655	50.3
Dental check-up	Yes	2,425	33.6
	No	5,044	66.4
Oral health status			
Periodontal status	CPI = 0	1,368	20.2
	CPI = 1–2	2,121	30.6
	CPI = 3–4	3,725	49.2
Number of missing teeth	3.93 (0.09)†		
Systemic disease			
COPD	Yes	1,134	12.8
	No	6,585	87.2
Total		7,719	100.0

COPD, chronic obstructive pulmonary disease; CPI, Community Periodontal Index.
†Data presented as mean (standard error).

DISCUSSION

With the aging global population, the frequency of chronic diseases has increased relative to infectious diseases that were more dominant in the past[4,5]. COPD is more common in the middle-aged and elderly populations with known risk factors such as smoking, recurrent respiratory infections, airway hypersensitivity, allergy, asthma and genetic factors[3].

Table 2 Participants' COPD status

Variables	Characteristics	COPD	Non-COPD	P^*
Sex	Male	827 (19.7)	2,415 (80.3)	< 0.001
	Female	307 (6.0)	4,170 (94.0)	
Age		62.63 ± 0.39	53.55 ± 0.17	< 0.001
Educational level	≤ Elementary school	424 (21.0)	1,611 (79.0)	< 0.001
	Middle school	184 (16.1)	889 (83.9)	
	High school	298 (10.3)	2,129 (89.7)	
	≥ University or College	180 (8.3)	1,635 (91.7)	
Household income	Low	360 (22.7)	1,189 (77.3)	< 0.001
	Middle–low	316 (13.9)	1,685 (86.1)	
	Middle–high	228 (10.8)	1,680 (89.2)	
	High	224 (8.6)	1,999 (91.4)	
Smoking	Never smoker	401 (7.7)	4,330 (92.3)	< 0.001
	Former smoker	414 (19.4)	1,264 (80.6)	
	Current smoker	305 (19.3)	900 (80.7)	
Alcohol consumption	< 1 per month	525 (12.2)	3,374 (87.8)	0.194
	≥ 1 per month	595 (13.3)	3,120 (86.7)	
Tooth brushing	< 3	653 (15.0)	3,164 (85.0)	< 0.001
	≥ 3	435 (10.1)	3,220 (89.9)	
Dental check-up	Yes	332 (10.9)	2,093 (89.1)	0.008
	No	755 (13.4)	4,289 (86.6)	
Periodontal status	CPI = 0	109 (6.7)	1,259 (93.3)	< 0.001
	CPI = 1–2	198 (8.8)	1,923 (91.2)	
	CPI = 3–4	750 (17.7)	2,975 (82.3)	
Number of missing teeth		7.43 ± 0.31	3.42 ± 0.09	< 0.001

Data are presented as the mean ± standard error for continuous variables or as *n* (%) for categorical variables.
COPD, chronic obstructive pulmonary disease; CPI, Community Periodontal Index.
*Chi-squared test or *t*-test.

Table 3 Association between oral health status and COPD

Variables	Model I†		Model II‡		Model III§		Model IV¶	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Periodontal status								
CPI = 0	1				1		1	
CPI = 1–2	2.240	1.867–2.687			1.345	1.027–1.761	1.045	0.783–1.395
CPI = 3–4	2.985	2.368–3.762			2.008	1.573–2.562	1.215	0.894–1.651
Number of missing teeth			2.081	1.971–2.190	1.865	1.654–2.076	1.316	1.202–1.529

OR and CI were calculated using the logistic regression analysis.
Response variable: COPD (ref. no.).
CI, confidence interval; CPI, Community Periodontal Index; OR, odds ratio.
†Explanatory variable in Model I: periodontal status.
‡Explanatory variable in Model II: number of missing teeth.
§Explanatory variables in Model III: periodontal status and number of missing teeth.
¶Explanatory variables in Model IV: periodontal status, number of missing teeth, demographic factors, socioeconomic factors, health factors, and oral health factors.

Periodontal disease as a risk factor for respiratory diseases, especially COPD[21], was reported more recently. Therefore, the present study aimed to assess the association between oral health status and COPD in Korean adults aged ≥ 40 years.

The present study found a higher COPD prevalence in individuals with the following characteristics; male sex, old age, low educational level, low household income, smokers, brushing teeth < 3 times per day, no dental check-up in the past year, periodontal disease, and a greater number of missing teeth. The prevalence of COPD in Korea has remained steady over the past several years. However, COPD prevalence increases with age and, as a result, the highest COPD prevalence is seen in individuals ≥ 60 years old[9]. Shin *et al.*[22] reported an association between the number of remaining teeth and COPD. A study by Park and Kim[23] found a higher prevalence of COPD in male smokers with increasing age. Smoking is a critical risk factor for COPD. Sharma and Shamsuddin[24] showed that smoking reduces ciliary activity against pathogens, and causes a fourfold increase in the prevalence of respiratory diseases like pneumonia. However, in general, the prevalence of COPD in males is fourfold higher than in females, regardless of age or smoking history[8].

Dental plaque is an important pathological factor in intraoral bacterial infection, the main cause of periodontal disease, and also affects an individuals'

general health[25]. Intraoral microbes associated with the teeth, intraoral tissues, fixed and removal restorations and saliva move into the lungs and cause respiratory disease along with respiratory pathogens[17]. According to a previous study[26], poor periodontal status increases the prevalence of COPD and may induce pathogenic pneumonia in patients already at high risk for respiratory infection. A cohort study demonstrated that increased periodontal attachment loss has a significant effect on the prevalence of COPD[16]. A meta-analysis[27] of nine CPI indices in COPD and non-COPD patients showed that COPD patients exhibited accelerated progressive worsening of periodontal health relative to non-COPD controls. On the other hand, the study by Marjanovic and Buhlin[28] did not identify a significant association between periodontal health and COPD in patients visiting dental hospitals.

In the present study, individuals with poor periodontal status exhibited a greater prevalence of COPD. However, after controlling for potential confounders (demographic, socioeconomic, health-related, and oral health-related factors), there was no significant association between periodontal status and COPD. Considering that the classification of periodontal status was based on the CPI we were not able to evaluate other periodontal conditions such as gingival recession and plaque accumulation. Thus, the association between periodontal status and COPD in this study must be interpreted with caution. However, it is also possible that our finding that the association between COPD and periodontal status is not significant, is a true negative.

Our results also revealed that individuals with missing teeth had a higher prevalence of COPD relative to those without missing teeth (OR, 2.081; CI, 1.97–2.19). Even after controlling for confounders, the outcome was similar to many previous studies. In a previous study[21], the authors found that individuals with < 20 teeth had a 4.18-fold higher prevalence of COPD compared with those with 28 teeth. Also, individuals with < 10 pairs of natural teeth exhibited a higher chance of having COPD compared with those with 14 pairs. Similarly, Shin *et al.*[22] found that individuals with 20–27 and 0–19 remaining teeth had a 1.90-fold and a 3.93-fold higher prevalence of COPD, respectively. The prospective cohort study by Barros *et al.*[19] showed a 2.28-fold higher risk of COPD in edentulous patients, and Wang *et al.*[12] reported a 1.05-fold greater prevalence of COPD with greater numbers of missing teeth.

Although our study did not find strong conclusive evidence between the association of periodontal status with COPD, periodontal disease is a major cause of tooth loss[12,18]. Our findings revealed a significant association between COPD and tooth loss, and hence the periodontal health of patients with COPD is also important. Lui *et al.*[2] mentioned that improved periodontal health might prevent COPD progression, and Zhou *et al.*[17] reported that periodontal treatment to reduce salivary bacteria and intraoral pathogens also reduces the prevalence of COPD. However, other studies have suggested no association between these two conditions[28–30], which is consistent with our study and, therefore, future longitudinal studies are required to confirm the outcomes reported here.

Despite the interesting findings outlined in the present study, our study design has several limitations that warrant some discussion. First, the KNHANES is a cross-sectional survey, therefore the causal relationship between oral health status and COPD was not assessed. Second, the various confounders could not be adjusted beyond the variables examined by the KNHANES. Finally, there were statistically significant differences between the COPD and non-COPD groups for general characteristics, indicating a questionable homogeneity between the groups. Because confounding factors were adjusted through the regression analysis, we believe that the potential non-homogeneity did not have much influence on our conclusions.

Despite its limitations, the present study offers several meaningful findings and advantages. We utilised a large national dataset that is likely highly representative of the broader Korean population. The present study is also one of very few studies in Korea that have assessed the association between oral health status (using CPI and numbers of missing teeth) and COPD. Future longitudinal studies assessing the causal relationship between oral health status and COPD should be performed.

Conflict of interest

The authors have no conflict of interest to declare.

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Correspondence to:
Yoon Young Choi, Department of Dental Hygiene, College of Bioecological Health, Shinhan University, Uijeongbu 11644, Korea.
Email: dencyy@naver.com