ORIGINAL RESEARCH

A Clinical and Radiographical Study to Assess and Correlate Chronic Obstructive Pulmonary Disease and Periodontitis

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Abstract

Aim: In the past few years, there has been accumulating evidence that suggests an exquisite association between oral infections and systemic diseases. Both chronic periodontitis and chronic obstructive pulmonary disease (COPD) are inflammatory conditions characterized by the loss of local connective tissue. The current study was conducted to find the association between COPD and periodontitis.

Materials and methods: The present cross-sectional study comprised of 60 individuals after obtaining their due consent. All the subjects enrolled were subjected to a spirometric test, from which COPD patients were graded into four categories A, B, C, and D according to their COPD status. A detailed periodontal examination was performed using parameters like probing pocket depth (PPD), clinical attachment level (CAL), plaque index (PI), and gingival index (GI). Orthopantomogram (OPG) of each individual was taken to assess the mean alveolar bone loss (MABL).

Results: The results showed that with the worsening of spirometric values (i.e., from A to D), there was a significant deterioration in the periodontal health in terms mean PPD, CAL, PI, GI, and MABL with a p value < 0.05.

Conclusion: The present study showed a positive association between COPD and periodontal health status. Periodontal health variables were considerably associated with the severity of COPD.

Clinical significance: It is essential to attach significance to the COPD patient's periodontal health. Active management of the periodontal disease may have more favorable effects on the COPD patients. Furthermore, exploring the effect and mechanism of the treatment of periodontal disease on the COPD is worthy of efforts.

Keywords: Bone loss, Chronic obstructive pulmonary disease, Periodontitis.

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Introduction

Respiratory diseases are widely prevalent and are responsible for a significant number of mortality and considerable suffering in humans. Chronic obstructive pulmonary disease (COPD) is the fourth leading cause of death in the world, and its prevalence and mortality are expected to increase in the coming decades. India contributes a significant and growing percentage of COPD mortality which is estimated to be amongst the highest in the world.[1] Chronic obstructive pulmonary disease is a common preventable and treatable disease that is characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and the lungs to noxious particles or gases.

Periodontal disease is primarily an oral bacterial infection with supervening inflammatory response leading to the breakdown of the supporting connective tissue, destruction of alveolar bone, and eventually tooth loss.[2,3] The prevalence of periodontal disease in India has been investigated by national research scholars since 1940. Shewale et al. in his systematic review stated that few areas of states like West Bengal, Uttar Pradesh, and Assam reported a prevalence rate of periodontal disease of more than 85% in their general population[4] with the highest prevalence to be 97.51%.[5] The oral cavity acts as a portal of entry and exit for oral pathogens as it is connected to the respiratory system through the trachea. Lower respiratory tract infections, including exacerbation of COPD, depend on the initial colonization of microbial pathogens on oral/pharyngeal surfaces.[6]

However, the nature of a relationship between periodontal disease and COPD remains unclear and the published literature on this specific relationship gives varied conclusions. Hence, the present study was conducted to evaluate the potential association between COPD and periodontal health status and to correlate the severity of periodontal disease with global initiative of obstructive lung disease (GOLD) categories of COPD using MABL.

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Materials and Methods

The present cross-sectional study was undertaken in the Department of Periodontology, Department of Pulmonary Medicine, Krishna Institute of Medical Sciences, Karad, after the due approval of the Ethical Committee (Ref. No. KIMSDU/IEC/03/2015, dated 10/12/2015). The study was conducted during the period from January 2016 to May 2017. All the subjects were informed about the study procedure in detail and were included in the study after

obtaining their due written consent. Sixty individuals suffering from COPD were selected for the study by purposive sampling technique.

Selection Criteria

Ambulatory COPD patients aged from 30 years to 60 years with no history of exacerbation in the last 3 months and with a minimum of 12 teeth present in their oral cavity were included in the study. Individuals suffering from any other systemic diseases, such as diabetes mellitus and osteoporosis, etc., that are known to influence periodontal status; history of periodontal treatment in the past 6 months; inability to perform lung function test; use of any medication known to influence the periodontal tissues; and pregnant or lactating women were excluded from the study.

Method of Collection of Data

The demographic details and relevant information of the subjects were recorded using a specially-designed case proforma which included medical history, past dental history, oral hygiene habits, history of usage of tobacco, and socioeconomic status. Weight and height of the subjects were measured to evaluate the body mass index (BMI = weight/(height)^2). All the subjects enrolled in the study were subjected to a spirometric test. A clip is placed on the patient's nose to keep both nostrils closed and a breathing mask is placed around their mouth. The patients are instructed to take a deep breath in, hold their breath for a few seconds, and then exhale as hard as possible into the breathing mask. This test is repeated at least three times to make sure that the results are consistent. The highest value amongst three close test readings is used as a final result. The assessments were done before and after 20 minutes of delivering a β2-agonist (salbutamol 5 mg/mL in 9% saline solution), through a nebulizer. Spirometry measures two key factors: expiratory forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). Forced vital capacity is the greatest total amount of air you can forcefully breathe out after breathing in as deeply as possible and FEV1 is the amount of air you can force out of your lungs in one second. The presence of a post bronchodilator FEV1/FVC <0.70 confirms the presence of persistent airflow limitation and thus of COPD in patients with appropriate symptoms. Based on the spirometric values and GOLD, COPD criteria patients were further graded into four categories (A, B, C, and D).[7]

A detailed dental examination was performed in the Department of Periodontology during which the parameters like PPD, CAL, and PI by Silness and Löe 1964, and GI by Löe and Silness 1963 were recorded. The subjects with habit of tobacco usage were referred to tobacco cessation center in the same institute for further counseling.

Evaluation of Radiographic Parameters

Orthopantomograms of all the study subjects were recorded using an OPG machine Xtropan 2000 (manufactured by VM Meditech Pvt Limited, Chennai, Tamil Nadu, India). The alveolar bone loss was measured using an OPG grid which was placed along with the film to standardize the measurements. The space between each radiopaque line of the grid was taken as 1 mm of bone loss. Bone loss was measured from the cementoenamel junction to the crest of the alveolar bone on the OPG. A minimum of two sites with the maximum bone loss in the posterior region of each quadrant was taken into consideration. Any grossly decayed tooth or root stumps were excluded from the study. The average bone loss was calculated by adding the total amount of bone loss (2 sites per quadrant) per patient and dividing it by eight, i.e., the number of sites considered.

All the data collected were statistically analyzed using Statistical Package for the Social Sciences (SPSS) software (version 20; IBM SPSS Inc., Chicago, IL, USA, 2011). The results were expressed in means and percentages; *p* value <0.05 was considered significant. The significance of difference in means was tested by analysis of variance (ANOVA) test. Tukey *post hoc* test was used to assess the difference in values between the different groups.

Results

In this cross-sectional study, the periodontal status of 60 COPD patients was assessed. Out of 60 COPD patients, 41 patients were male (68.30%) and 19 patients were female (31.70%). The mean age (SD) and BMI (SD) of the study population were 53.90 (5.36) and 23.26 (3.95), respectively. Forty-eight individuals had a monthly income of less than Rs. 10,000 (80%) per month whereas 12 individuals had a monthly income of more than Rs. 10,000 (20%), which denotes that the majority of the study population belonged to the poor socioeconomic background.[8] On examining the smoking status of the subjects, it was found that 57 subjects (95%) were nonsmokers and 3 individuals (5%) were current smokers.

Around 89% of the study population used horizontal scrub motion while cleaning their teeth. Only 12% of the subjects undergo scaling twice in a year, 24% once in a year, and 76% have not undergone scaling for more than 2 years.

The percentage distribution of the study population as per GOLD categories is mentioned in Table 1. One-way ANOVA test was performed to test the differences between mean values of PPDs, CAL, PI, GI, and MABL amongst GOLD categories. It was found that there was a statistically significant difference in the PPD, CAL, PI, GI, and MABL values amongst GOLD COPD groups with a *p* value <0.05 as shown in Tables 2 to 6, respectively. Intergroup comparison of GOLD

Table 1: Percentage distribution of study population as per global initiative of obstructive lung disease categories

GOLD COPD	*Frequency*	*Percent*
A	15	25.00
B	15	25.00
C	12	20.00
D	18	30.00

Table 2: Assessment of mean probing pocket depth of GOLD chronic obstructive pulmonary disease categories using ANOVA

	PPD			
GOLD COPD category	*Mean*	*Std. Dev.*	*F*	*p value*
A	3.94	0.66	44.90	0.00*
B	4.21	0.54		
C	5.61	0.55		
D	8.57	2.19		
Intergroup comparison of GOLD COPD categories using Tukey *post hoc* test				
A	B			0.942
	C			0.009*
	D			0.000*
B	C			0.037*
	D			0.000*
C	D			0.000*

*Statistically significant

Table 3: Assessment of mean CAL of GOLD COPD categories using ANOVA

	RAL			
GOLD COPD category	*Mean*	*Std. Dev.*	*F*	*p value*
A	3.21	1.20	45.99	0.00*
B	4.59	1.71		
C	6.77	1.14		
D	11.36	3.29		
Intergroup comparison of GOLD COPD categories using Tukey *post hoc* test				
A	B			0.304
	C			0.000*
	D			0.000*
B	C			0.055*
	D			0.000*
C	D			0.000*

*Statistically significant

Table 4: Assessment of mean plaque index of GOLD COPD categories using ANOVA

	PI			
GOLD COPD category	*Mean*	*Std. Dev.*	*F*	*p value*
A	1.40	0.51	18.20	0.00*
B	2.59	0.86		
C	3.73	0.40		
D	6.18	3.43		
Intergroup comparison of GOLD COPD categories using Tukey *post hoc* test				
A	B			0.348
	C			0.017*
	D			0.000*
B	C			0.455
	D			0.000*
C	D			0.008*

*Statistically significant

Table 5: Assessment of mean gingival index of GOLD COPD categories using ANOVA

	GI			
GOLD COPD category	*Mean*	*Std. Dev.*	*F*	*p value*
A	1.57	0.49	20.99	0.00*
B	2.51	0.78		
C	2.98	0.39		
D	5.98	2.98		
Intergroup comparison of GOLD COPD categories using Tukey *post hoc* test				
A	B			0.435
	C			0.155
	D			0.000*
B	C			0.895
	D			0.000*
C	D			0.000*

*Statistically significant

Table 6: Assessment of mean alveolar bone loss of GOLD COPD categories using ANOVA

	MABL			
GOLD COPD category	*Mean*	*Std. Dev.*	*F*	*p value*
A	2.03	0.39	101.53	0.00*
B	3.21	0.36		
C	3.89	0.32		
D	4.86	0.67		
Intergroup comparison of GOLD COPD categories using Tukey *post hoc* test				
A	B			0.000*
	C			0.000*
	D			0.000*
B	C			0.002*
	D			0.000*
C	D			0.000*

*Statistically significant

categories was performed using the Tukey *post hoc* test which showed statistical significance amongst all the groups on the comparison of MABL (Table 6).

Discussion

The concept of linking periodontitis and systemic diseases is not new.[9] The association between periodontal diseases and COPD has gained attention owing to the fact that both these diseases share the same pathophysiology and common risk factors.

Existing literature suggests that the risk of developing COPD and periodontal health is inversely related to socioeconomic status.[10,11] In the current study, we have observed similar results as majority of our subjects belonged to low socioeconomic strata. There was a strong association between education level and socioeconomic status with periodontal health in our study subjects.[11] Poor oral hygiene status observed amongst the study population could be attributed to faulty toothbrushing method, lower regular supragingival scaling and poorer oral health knowledge amongst the study population, which was evident through the data obtained in the specially designed case proforma. Similar reasons were elicited for the poor periodontal health status in a study conducted by Newman et al.[12] Poor oral hygiene results in an increase in mass and complexity of dental plaque, which may foster bacterial interactions between indigenous plaque bacteria and acknowledged respiratory pathogens, which are shed into saliva.[13]

The literature suggests that chronic periodontitis may influence the course of respiratory infection. Some of the recently published studies have found poor periodontal health in patients who suffered from COPD as compared to healthy controls.[14–16]

Similarly, Shen et al. in his nationwide population-based cohort study had observed that there was an increased risk of periodontal diseases in patients with COPD.[17] A positive association between COPD and chronic periodontitis was observed in our current study which is in accordance with studies conducted by Madalli et al. and VikasDeo et al., and others.[18–21] On the contrary to the abovementioned observations, Takahashi et al., Hayes et al., and Russell et al. had observed a weak association between periodontal diseases and COPD.[22–24]

Studies carried out by Peter et al. and Hyman et al. revealed a strong association of smoking with COPD and periodontitis.[25,26]

However, Thomsen et al. reported that never-smokers with COPD had different characteristics and milder diseases, limited to the lungs. However, the morbidity levels were substantial in never-smokers with COPD.[27] Thus, smoking can be a major confounding factor in the studies that attempt to prove an association between periodontal disease and COPD. Smoking was not a significant confounding factor in our study as a majority of the study subjects were nonsmokers.

In the current study, there was a positive correlation between PI and GI, and lung obstruction. Thus, mean PI and GI values were higher in group IV when compared to group I. These findings were similar to the study conducted by Sharma et al. and Benazir et al., who reported that the mean PI and GI were higher in COPD patients as compared to healthy controls.[28,29] A negative correlation was observed between PI and GI values, and lung obstruction in the studies conducted by Prafulla et al. and Scannapieco et al., whose observations were not in accordance with our study.[25,30] The worsening of the abovementioned periodontal indices (PI and GI) that were measured in the current study could be attributed to the inappropriate oral hygiene method, lack of professional care, and poorer oral health knowledge amongst the study population.

In the current study, mean PPD and CAL values among the four GOLD COPD categories were highest in category D followed by categories C, B, and A, respectively. Thus, it is clear that there was deterioration in the periodontal health as the spirometric values worsened. These findings are in accordance with the study conducted by Prafulla et al., Hayes et al., Sharma et al., Scannapieco et al. and Bhavsar et al., and Tan et al., wherein there was a positive correlation between lung obstruction and PPD and CAL.[23,25,28,31–33] In contrary, the study conducted by Hyman and Katancik et al. had shown an insignificant association between lung obstruction and PPD.[26,34] A recent systematic review indicated that at present there is no sufficient information to ascertain the association between periodontal disease and COPD in terms of RAL which was contradictory to our study.[35]

It was observed in our study that there was an increase in the MABL with the worsening of spirometric values. This observation corroborates the study conducted by Leuckfeld et al. and Hayes et al.[23,36] One mechanism proposed for gross airway epithelial damage observed in COPD involves the release of proinflammatory cytokines (interleukin-8) from respiratory epithelium.[37] This subsequently results in recruitment and infiltration by neutrophils that then release proteolytic enzymes and toxic oxygen radicals which eventually leads to the destruction of connective tissue including alveolar bone.

On intergroup comparison between GOLD categories A and B in the current study, there was no statistically significant difference in PPD, CAL, PI, and GI scores. Groups II and III did not show statistical significance on intergroup comparison with regards to PI and GI. Whereas MABL value between all the groups showed statistical significance with a *p* value less than 0.05. The lack of statistical significance on intergroup comparison of periodontal parameters among the GOLD categories could be attributed to the smaller sample size in the different GOLD COPD categories.

Several mechanisms have been proposed for the association between these two highly common diseases. Dental plaque provides a reservoir for respiratory pathogen colonization that can be shed into saliva. Saliva containing such organisms might contaminate the distal portion of the respiratory tree, resulting in pulmonary infections. It is of great significance that the majority of pulmonary diseases are attributable to aerobic bacteria that are found in the oral flora in any oral diseases.[38] On the contrary, some of the facultative anaerobes that are responsible for the periodontal breakdown, also have been isolated from infected lungs.[39,40] Furthermore, cytokines released during the progression of chronic periodontitis by infected periodontal tissues may alter respiratory epithelium.

The strength of this study rests in the fact that individuals enrolled were those having only COPD and no other systemic disease that influences periodontal health, and all participants were noninstitutionalized ambulatory individuals whose quality of life was not disturbed. The probable crucial confounders could be the inclusion of subjects with smoking or history of tobacco usage and the socioeconomic background. However, caution must be taken in interpreting the applicability of the current data until these findings can be confirmed by larger prospective multicentered investigations. Future studies can compare the inflammatory profiles of patients to determine the effect of treating periodontitis in COPD-related lung disease.

Conclusion

The results of the present analysis indicate that, with the worsening of spirometric values, there was deterioration in the periodontal parameters. It is understood that poor oral health (periodontitis) alone is not responsible for COPD, rather poor oral health may work as an adjunct with other factors (such as continued smoking, environmental pollutants, viral infections, allergies, and/or genetic factors) to promote the progression and/or exacerbation of COPD. Further longitudinal and interventional, molecular biologic studies would be required to establish the role of oral health in the progression of COPD. In future, periodontists may be able to play a significant role in the prevention of respiratory diseases by redoubling their efforts to prevent periodontitis, which will improve the quality of life in patients with periodontitis and COPD.

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References

1. Lopez AD, Shibuya K, Rao C, et al. Chronic obstructive pulmonary disease: current burden and future projections. Eur Respir J 2006;27(2):397–412. DOI: 10.1183/09031936.06.00025805.
2. Kornman KS. Mapping the pathogenesis of periodontitis: a new look. J Periodontol 2008;79(8S):1560–1568. DOI: 10.1902/jop.2008.080213.
3. Pihlstrom BL, Michalowicz BS, Johnson NW. Periodontal diseases. Lancet 2005;366(9499):1809–1820. DOI: 10.1016/S0140-6736(05)67728-8.
4. Shewale AH, Gattani DR, Bhatia N, et al. Prevalence of Periodontal Disease in the General Population of India-A Systematic Review. J Clin Diagn Res 2016;10(6):ZE04–ZE09. DOI: 10.7860/JCDR/2016/17958.7962.
5. Kundu D, Mehta R, Rozra S. Periodontal status of a given population of West Bengal: an epidemiological study. J Indian Soc Periodontol 2011;15(2):126–129. DOI: 10.4103/0972-124X.84380.
6. Rose LF, Genco RJ, Mealey BF, et al. Periodontal Medicine. Hamilton, Ontario: B.C. Decker Inc.; 2000. pp. 83–98. https://theeye.eu/public/Books/Medical/texts/Periodontics%20%20Medicine%2C%20Surgery%20and%20Implants%20%20L.%20Rose%2C%20et%20al.%2C%20%28Mosby%2C%202004%29%20WW.pdf.
7. Pauwels RA, Buist AS, Calverley PM, et al. GOLD Scientific Committee. Global strategy for the diagnosis, management, and prevention of

chronic obstructive pulmonary disease. NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. Am J Respir Crit Care Med 2001;163:1256–1276. DOI: 10.1164/ajrccm.163.5.2101039.
8. Oberoi SS. Updating income ranges for Kuppuswamy's socio-economic status scale for the year 2014. Indian J Public Health 2015;59(2):156–157. DOI: 10.4103/0019-557X.157540.
9. Lindhe J, Karring T, Niklaus P. Textbook of Clinical Peridontology and Implant Dentistry. New Delhi: Blackwell Munksgaard a Blackwell publishing Company; 2003. pp. 366–381. https://theeye.eu/public/Books/Medical/texts/Clinical%20Periodontology%20and%20Implant%20Dentistry%204th%20ed%20%20J.%20Lindhe%20%28Blackwell%2C%202003%29%20WW.pdf.
10. Gershon AS, Warner L, Cascagnette P, et al. Lifetime risk of developing chronic obstructive pulmonary disease: a longitudinal population study. Lancet 2011;378(9795):991–996. DOI: 10.1016/S0140-6736(11)60990-2.
11. Gundala R, Chava VK. Effect of lifestyle, education and socioeconomic status on periodontal health. Contemp Clin Dent 2010;1(1):23–26. DOI: 10.4103/0976-237X.62516.
12. Newman JF, Gift HC. Regular pattern of preventive dental services. A measure of access. Soc Sci Med 1992;35(8):997–1001. DOI: 10.1016/0277-9536(92)90239-M.
13. Georgiou TO, Marshall RI, Barlod PM. Prevalence of systemic diseases in Brisbane general and periodontal practice patients. Aust Dent J 2004;49(4):177–184. DOI: 10.1111/j.1834-7819.2004.tb00070.x.
14. Chung JH, Hwang HJ, Kim SH, et al. Associations Between periodontitis and chronic obstructive pulmonary disease: the 2010 to 2012 Korean National Health and Nutrition Examination Survey. J Periodontol 2016;87(8):864–871. DOI: 10.1902/jop.2016.150682.
15. Shi Q, Zhang B, Xing H, et al. Patients with chronic obstructive pulmonary disease suffer from worse periodontal health-evidence from a meta-analysis. Front Physiol. 2018;9:33. DOI: 10.3389/fphys.2018.00033.
16. Lopez de Andres A, Vazquez-Vazquez L, Huedo M, et al. Is COPD associated with periodontal disease? A population-based study in Spain. Int J Chron Obstruct Pulmon Dis 2018;13:3435–3445. DOI: 10.2147/COPD.S174898.
17. Shen TC, Chang PY, Lin CL, et al. Risk of periodontal diseases in patients with chronic obstructive pulmonary disease: a nationwide population-based cohort study. Medicine 2015;94(46):e2047. DOI: 10.1097/MD.0000000000002047.
18. Madalli R, Kheur S, Reddy MG, et al. Assessment of role of Porphyromonasgingivalis as an aggravating factor for chronic obstructive pulmonary disease patients with periodontitis. Dent Hypotheses 2016;7(3):100–106. DOI: 10.4103/2155-8213.190485.
19. Deo V, Bhongade ML, Ansari S, et al. Periodontitis as a potential risk factor for chronic obstructive pulmonary disease: a retrospective study. Indian J Dent Res 2009;20(4):466–470. DOI: 10.4103/0970-9290.59456.
20. Zeng XT, Tu ML, Liu DY, et al. Periodontal disease and risk of chronic obstructive pulmonary disease: a meta-analysis of observational studies. PLoS One. 2012;7(10):e46508. DOI: 10.1371/journal.pone.0046508.
21. Usher AK, Stockley RA. The link between chronic periodontitis and COPD: a common role for the neutrophil? BMC Med. 2013;11:241. DOI: 10.1186/1741-7015-11-241.
22. Takahashi T, Muro S, Tanabe N, et al. Relationship between periodontitis-related antibody and frequent exacerbations in chronic obstructive pulmonary disease. PLoS One 2012;7(7):e40570. DOI: 10.1371/journal.pone.0040570.
23. Hayes C, Sparrow D, Cohen M, et al. The association between alveolar bone loss and pulmonary function: the VA Dental Longitudinal Study. Ann Periodontol 1998;3(1):257–261. DOI: 10.1902/annals.1998.3.1.257.
24. Russell SL, Boylan RJ, Kaslick RS, et al. Respiratory pathogen colonization of the dental plaque of institutionalized elders. Spec Care Dentist 1999;19(3):128–134. DOI: 10.1111/j.1754-4505.1999.tb01413.x.
25. Peter KP, Mute BR, Doiphode SS, et al. Association between periodontal disease and chronic obstructive pulmonary disease: a reality or just a dogma? J Periodontol 2013;84(12):1717–1723. DOI: 10.1902/jop.2013.120347.
26. Hyman JJ, Reid BC. Cigarette smoking, periodontal disease: And chronic obstructive pulmonary disease. J Periodontal 2004;75(1):9–15. DOI: 10.1902/jop.2004.75.1.9.
27. Thomsen M, Nordestgaard BG, Vestbo J, et al. Characteristics and outcomes of chronic obstructive pulmonary disease in never smokers in Denmark: a prospective population study. Lancet Respir Med 2013;1(7):543–550. DOI: 10.1016/S2213-2600(13)70137-1.
28. Sharma N, Shamsuddin H. Association between respiratory disease in hospitalized patients and periodontal disease: a cross-sectional study. J Periodontol. 2011;82(8):1155–1160. DOI: 10.1902/jop.2011.100582.
29. Benazir G, Bhattacharya HS. To Evaluate Association Between Periodontal Disease and Chronic Obstructive Pulmonary Disease. Indian J Dent Sci 2014;1(6):41–44.
30. Scannapieco FA, Papandonatos GD, Dunford RG. Associations between oral conditions and respiratory disease in a national sample survey population. Ann Periodontol 1998;3(1):251–256. DOI: 10.1902/annals.1998.3.1.251.
31. Scannapieco FA, Ho AW. Potential associations between chronic respiratory disease and periodontal disease: analysis of National Health and Nutrition Examination Survey III. J Periodontol 2001;72(1):50–56. DOI: 10.1902/jop.2001.72.1.50.
32. Bhavsar NV, Dave BD, Brahmbhatt NA, et al. Periodontal status and oral health behavior in hospitalized patients with chronic obstructive pulmonary disease. J Nat Sci Biol Med 2015;1:33–41.
33. Tan L, Tang X, Pan C, et al. Relationship among clinical periodontal, microbiologic parameters and lung function in participants with chronic obstructive pulmonary disease. J Periodontol 2019;90(2):134–140. DOI: 10.1002/JPER.17-0705.
34. Katancik JA, Kritchevsky S, Weyant RJ, et al. Periodontitis and airway obstruction. J Periodontol 2005;76(11S):2161–2167. DOI: 10.1902/jop.2005.76.11-S.2161.
35. Scannapieco FA, Bush RB, Paju S. Association between periodontal diseases and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease: A systematic review. Ann Periodontol 2003;8(1):54–69. DOI: 10.1902/annals.2003.8.1.54.
36. Leuckfeld I, Obregon-Whittle MV, Lund MB, et al. Severe chronic obstructive pulmonary disease: association with marginal bone loss in periodontitis. Respir Med 2008;102(4):488–494. DOI: 10.1016/j.rmed.2007.12.001.
37. Scannapieco FA. Role of oral bacteria in respiratory infection. J Periodontol. 1999;70:793–802. DOI: 10.1902/jop.1999.70.7.793.
38. Morris AJ, Steele J, White DA. The oral cleanliness and periodontal health of UK adults in 1998. Br Dent J 2001;191:186–192. DOI: 10.1038/sj.bdj.4801135.
39. Taylor J, Pike R, Imamura I, et al. The role of proteolytic enzymes in the development of pulmonary emphysema and periodontal disease. Am J Respir Crit Care Med 1994;150(6_pt_2):S143–S146. DOI: 10.1164/ajrccm/150.6_Pt_2.S143.
40. Wu X, Chen J, Xu M, et al. 16S rDNA analysis of periodontal plaque in chronic obstructive pulmonary disease and periodontitis patients. J Oral Microbiol 2017;9(1):1324725. DOI: 10.1080/20002297.2017.1324725.