

# Association between the number of prosthetic crowns and periodontitis: a cross-sectional study

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## Research Article

**Keywords:** Cross-sectional study, Periodontitis, Prosthetic crowns, Oral health, Oral hygiene, Prevention

**Posted Date:** February 15th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-183824/v1>

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# Abstract

## Background

Although the presence of prosthetic restorations has been associated with plaque accumulation, gingivitis, and periodontitis, there is a lack of large epidemiological investigations providing credible evidence on the association of prosthetic crowns with periodontitis. The purpose of the study was to analyze the association between the number of prosthetic crowns and the presence of periodontitis.

## Methods

This study was based on the Seventh Korea National Health and Nutrition Examination Survey (2016-2018). A total of 12,689 participants over the age of 19 years were surveyed. Multivariate logistic regression analyses were used to identify the association between the number of prosthetic crowns and periodontitis after adjusting for potential confounders, including demographic variables, socio-economic characteristics, oral health-related variables, and oral and systemic clinical variables.

## Results

The odds ratio of periodontitis showed statistically significant differences in the anterior and posterior regions, and the prevalence of periodontal disease increased as the number of crown prostheses increased. Participants with 6–10 and 11 prosthetic crowns had 1.24 and 1.28 times higher prevalence of periodontitis, respectively, than patients with no prosthetic crown.

## Conclusions

The results of this study show that the number of prosthetic crowns present in adults is related to the prevalence of periodontitis.

## Background

Periodontitis refers to host-mediated inflammation associated with bacterial biofilm that causes loss of periodontal attachment [1]. The initiation and progression of periodontitis is dependent on the ecological changes caused by dysbiosis of microorganisms that develops as anti-bacterial mechanisms generating inflammation and tissue destruction in the gingival sulcus [2]. As periodontitis progresses, there is crestal bone resorption along with loss of attachment caused by inflammatory mediators, and the depth of the periodontal pocket increases.

The presence of prostheses, along with the anatomy, position, and the relationships of the teeth with each other, is associated with plaque accumulation and subsequent gingivitis and periodontitis [3]. The process of fabrication and delivery of tooth-supported prostheses also has the potential to affect periodontal tissues by causing trauma or due to allergic reactions to dental materials [4]. It has been reported that deeper the placement of the subgingival crown margin in the gingival sulcus, more severe is

the gingival inflammation [5]. Additionally, long-term observations have shown that loss of attachment rapidly progresses between one and three years after placing subgingival restorations [6]. Other studies have reported that the subgingival margin design of prostheses affects the adjacent periodontal tissue in terms of bleeding on probing and gingival recession [7]. It is also widely known that overhanging restorations cause gingival inflammation and interproximal bone loss [8, 9]. These observations are derived from the premise that it is not easy to control the plaque around the subgingival margin and the overhanging prosthesis.

Nevertheless, till date, there are no large epidemiological investigations providing credible evidence on the association of prosthetic crowns with periodontitis. The Korea National Health and Nutrition Survey (KNHANES) collects data on diseases and nutrition of 7,000 people annually, generating national statistics every three years. In its seventh edition or the KNHANES VII survey, oral examinations were performed on the tooth surface in accordance with the World Health Organization (WHO) survey criteria [10], and the number of prosthetic crowns for each participant were determined. Further, the community periodontal index (CPI) was recorded to assess the periodontal status [11]. The present study analyzed the association between the presence of periodontitis and the number of fixed prostheses in individuals based on the results of the KNHANES.

## Methods

This study used data acquired from KNHANES VII, which was a cross-sectional and nationally representative survey conducted by the Korea Centers for Disease Control and Prevention (KCDC) between 2016 and 2018. This study is based on the data from the Seventh Korea National Health and Nutrition Examination Survey (KNHANES VII: 2016–2018). KNHANES VII is a national cross-sectional survey conducted by the Korean Disease Control and Prevention Agency (KDCA) The survey protocols and secondary use of data were approved by the Institutional Review Board of the KDCA (IRB No. 2018-01-03-P-A). All the study participants provided written informed consent.

The sampling protocol used was a complex, stratified, multistage probability cluster survey of a representative sample of the non-institutionalized civilian population of Korea. A total of 12,689 participants (8,708 males and 3,981 females), aged 19 years or older, completed the KNHANES VII. Individuals without data on periodontitis, age, and sex were excluded from the analysis. From all the data collected by the KNHANES VII, we used the data on socio-demographic characteristics (age, sex, household income, and level of education), oral health-related variables (toothbrushing, interdental brush use, dental floss use, dental clinic visits, and CPI), oral and systematic medical factor variables (smoking, diabetes mellitus [DM], hypercholesterolemia, hypertension, and body mass index (BMI)), and the number of prosthetic crowns.

### Periodontal examination

Periodontal status was evaluated using the CPI probe developed by the WHO [12]. A CPI probe that met the 1997 WHO guidelines [10] was used on ten index teeth, two molars in each posterior sextant, and the

upper right and lower left central incisors at six sites per tooth (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual). The periodontal pocket depth was measured. Probing was done by dentists trained in calibration. The five recorded CPI scores were as follows: CPI 0, normal; CPI 1, gingival bleeding; CPI 2, presence of gingival calculus; CPI 3, shallow periodontal pocket ( $> 3.5$  mm and  $\leq 5.5$  mm), and CPI 4, deep periodontal pocket ( $> 5.5$  mm). Periodontitis was defined as a CPI score of 3 or 4. Participants were classified into two groups: non-periodontitis and periodontitis group.

### Number of crowned teeth

Evaluation of the number of crowns examined by the WHO oral health examination method [10] was based on the treatment of all surfaces of the tooth. Crowns with and without caries were included in the analysis. The number of crowns in the anterior and posterior regions was divided, taking into account the clinical characteristics of each region. The anterior teeth were categorized into two groups based on the median number of crowns, and the molars were classified into one, or, two-three, four-five, or six according to the interquartile range.

### Covariates

The covariates of this study were the following major sociodemographic factors: sex, age, household income, and education [13]. Household income was classified as  $< 25\%$  (the lowest quartile group),  $25\text{--}49\%$ ,  $50\text{--}74\%$ , and  $75\text{--}100\%$  (the highest quartile group). Education level was classified into four groups based on the Korean education system: below primary school, middle school, high school, and college or higher education. The oral health variables were toothbrushing, interdental brushing, dental flossing, and dental clinic visits. The systematic medical factor variables were smoking, DM, hypercholesterolemia, hypertension, and BMI. Participants were categorized into two groups based on their smoking experience: “non-smoker” and “current or past smoker.” With respect to DM, participants were classified into three groups: normal, impaired fasting glucose, and diabetic. The systemic medical factors included in the analysis were DM, hypercholesterolemia, hypertension, and obesity. With respect to DM, participants were classified into three groups defined as: a fasting plasma glucose level  $\geq 126$  mg/dL, a previous diagnosis of diabetes by a physician, or current use of anti-diabetic agents or insulin. Hypercholesterolemia was defined as a total plasma cholesterol level of  $\geq 240$  mg/dL or current use of cholesterol-lowering agents. Hypertension was defined as an average SBP/DBP  $\geq 140/90$  mmHg or the use of antihypertensive agents. Based on the WHO redefined criteria for obesity in the Asia-Pacific region, obesity was defined as a BMI of  $\geq 25$  kg/m<sup>2</sup>.

## Statistical analysis

Data were analyzed using SPSS version 23.0 (SPSS, Chicago, IL). All data were weighted for statistical analyses to account for the complex multistage, stratified, and unequally weighted or clustered sampling design of the KNHANES VII. Appropriate sample weighting factors were selected as specified for each national dataset. The chi-square test and independent t-test were used to compare the characteristics of subjects in the periodontitis and non-periodontitis groups. Multivariate logistic regression analyses were

used to identify associations between the number of prosthetic crown teeth and periodontitis after adjusting for potential confounders. Regression model 1 was adjusted for age and sex. Household income and level of education were added to regression model 2. Oral health variables (toothbrushing, interdental brushing, dental flossing, and dental clinic visits) were added to regression model 3. Systematic medical factor variables (smoking, DM, hypercholesterolemia, hypertension, and BMI) were added to regression model 4. Other multivariate logistic regression analyses were performed to identify the modifiers, such as sex and age, after adjusting for potential confounders in model 4.  $P < 0.05$  was considered statistically significant.

## Results

### Demographics and clinical characterization

Table 1 shows characteristics of the study population in this study, stratified by the number of prosthetic crowns. A total of 12,689 participants were included, 5545 were males and 7144 were females. Participants included 12,059 adults aged 19–64 years and 11,406 elderly subjects aged 65 years and above. People with dental prosthetic crowns accounted for 31.3% of the total population.

Table 1  
 Characteristics of the study population stratified by periodontitis

Variables	Periodontitis <sup>1)</sup>				P-value
	Normal		Periodontitis		
	Unweighted N	Weighted % (95% CIs)	Unweighted N	Weighted % (95% CIs)	
Age (Mean ± SD)	8,708	46.78 ± 0.31	3,981	58.87 ± 0.33	< 0.001
Sex					< 0.001
Male	3,417	37.8 (36.8–38.9)	2,128	52.1 (50.4–53.8)	
Female	5,291	62.2 (61.1–63.2)	1,853	47.9 (46.2–49.6)	
Income					< 0.001
Low	1,331	15.1 (13.8–16.6)	1,009	25 (22.7–27.4)	
Middle low	2,011	22.8 (21.4–24.3)	1,077	27.2 (25.4–29.1)	
Middle high	2,552	29.1 (27.7–30.6)	992	25.1 (23.3–26.9)	
High	2,796	33 (30.9–35.1)	888	22.7 (20.5–25.1)	
Education					< 0.001

1) Periodontitis was defined as community periodontal index codes 3, 4

2) Oral health care products were usually used

3) Dental clinic visits within a year

4) Hypercholesterolemia was defined by total cholesterol  $\geq$  240 mg/dL or current use of drugs for lowering cholesterol.

5) Impaired fasting glucose was defined as  $100 \text{ mg/dL} \leq$  fasting blood glucose  $< 126 \text{ mg/dL}$ , and diabetes was defined by fasting blood glucose  $\geq 126 \text{ mg/dL}$  or current use of anti-diabetic drugs or insulin.

6) Prehypertension was defined as  $140 \text{ mmHg} >$  systolic blood pressure  $\geq 130 \text{ mmHg}$  or  $90 \text{ mmHg} >$  diastolic blood pressure  $\geq 85 \text{ mmHg}$ , and hypertension was defined as systolic blood pressure  $\geq 140 \text{ mmHg}$  or diastolic blood pressure  $\geq 90 \text{ mmHg}$  or drug.

Variables	Periodontitis <sup>1)</sup>				P-value
	Normal		Periodontitis		
	Unweighted N	Weighted % (95% CIs)	Unweighted N	Weighted % (95% CIs)	
≤ Elementary school	1,172	13.4 (12.2–14.6)	1,147	29.8 (27.4–32.3)	
Middle school	654	7.8 (7–8.7)	522	14.7 (13.2–16.3)	
High school	2,827	34.7 (33.3–36.3)	1,134	30.4 (28.3–32.5)	
≥ University or college	3,686	44 (42.1–46)	968	25.1 (22.9–27.5)	
Smoking					< 0.001
Everyday	1,303	14.8 (13.8–15.8)	969	23.8 (22.2–25.5)	
Occasionally	1,634	18.3 (17.4–19.2)	988	24.7 (23.1–26.4)	
Never	5,699	66.9 (65.7–68.2)	1,978	51.5 (49.7–53.3)	
Daily Toothbrushing					< 0.001
No	89	1 (0.8–1.3)	80	2.1 (1.7–2.7)	
Yes	8,545	99 (98.7–99.2)	3,855	97.9 (97.3–98.3)	

1) Periodontitis was defined as community periodontal index codes 3, 4

2) Oral health care products were usually used

3) Dental clinic visits within a year

4) Hypercholesterolemia was defined by total cholesterol  $\geq$  240 mg/dL or current use of drugs for lowering cholesterol.

5) Impaired fasting glucose was defined as  $100 \text{ mg/dL} \leq$  fasting blood glucose  $< 126 \text{ mg/dL}$ , and diabetes was defined by fasting blood glucose  $\geq 126 \text{ mg/dL}$  or current use of anti-diabetic drugs or insulin.

6) Prehypertension was defined as  $140 \text{ mmHg} >$  systolic blood pressure  $\geq 130 \text{ mmHg}$  or  $90 \text{ mmHg} >$  diastolic blood pressure  $\geq 85 \text{ mmHg}$ , and hypertension was defined as systolic blood pressure  $\geq 140 \text{ mmHg}$  or diastolic blood pressure  $\geq 90 \text{ mmHg}$  or drug.

Variables	Periodontitis <sup>1)</sup>				P-value
	Normal		Periodontitis		
	Unweighted N	Weighted % (95% CIs)	Unweighted N	Weighted % (95% CIs)	
Flossing <sup>1)</sup>					< 0.001
No	6,168	71.2 (69.8–72.5)	3,368	85.4 (83.8–86.8)	
Yes	2,467	28.8 (27.5–30.2)	568	14.6 (13.2–16.2)	
Interdental brushing <sup>1)</sup>					< 0.001
No	6,833	78.9 (77.8–79.9)	3,355	85.9 (84.6–87.2)	
Yes	1,802	21.1 (20.1–22.2)	581	14.1 (12.8–15.4)	
Dental clinic visits <sup>2)</sup>					0.082
No	3,555	41.1 (39.8–42.4)	1,689	43.1 (41.2–45)	
Yes	5,078	58.9 (57.6–60.2)	2,245	56.9 (55–58.8)	
Diabetes <sup>3)</sup>					< 0.001
Normal	5,793	70.7 (69.4–71.9)	1,859	51.4 (49.4–53.4)	

1) Periodontitis was defined as community periodontal index codes 3, 4

2) Oral health care products were usually used

3) Dental clinic visits within a year

4) Hypercholesterolemia was defined by total cholesterol  $\geq$  240 mg/dL or current use of drugs for lowering cholesterol.

5) Impaired fasting glucose was defined as  $100 \text{ mg/dL} \leq$  fasting blood glucose  $< 126 \text{ mg/dL}$ , and diabetes was defined by fasting blood glucose  $\geq 126 \text{ mg/dL}$  or current use of anti-diabetic drugs or insulin.

6) Prehypertension was defined as  $140 \text{ mmHg} >$  systolic blood pressure  $\geq 130 \text{ mmHg}$  or  $90 \text{ mmHg} >$  diastolic blood pressure  $\geq 85 \text{ mmHg}$ , and hypertension was defined as systolic blood pressure  $\geq 140 \text{ mmHg}$  or diastolic blood pressure  $\geq 90 \text{ mmHg}$  or drug.

Variables	Periodontitis <sup>1)</sup>				P-value
	Normal		Periodontitis		
	Unweighted N	Weighted % (95% CIs)	Unweighted N	Weighted % (95% CIs)	
Impaired fasting glucose	1,725	21.2 (20.2–22.2)	1,119	28.6 (27–30.3)	
Diabetes	701	8.1 (7.4–8.9)	765	20 (18.5–21.6)	
Hypercholesterolemia <sup>4)</sup>					< 0.001
Normal	6,584	79.8 (78.7–80.9)	2,734	72.8 (71.1–74.3)	
Abnormal	1,650	20.2 (19.1–21.3)	1,009	27.2 (25.7–28.9)	
Hypertension <sup>5)</sup>					< 0.001
Normal	4,440	51.5 (50.1–52.9)	1,180	29.9 (28.1–31.8)	
Prehypertension	2,084	24.1 (23.1–25.2)	1,005	25.4 (23.9–27)	
Hypertension	2,167	24.3 (23–25.7)	1,786	44.6 (42.6–46.7)	
BMI	23.63 ± 0.05		24.47 ± 0.07		< 0.001
Number of prosthetic crowns					< 0.001

1) Periodontitis was defined as community periodontal index codes 3, 4

2) Oral health care products were usually used

3) Dental clinic visits within a year

4) Hypercholesterolemia was defined by total cholesterol  $\geq$  240 mg/dL or current use of drugs for lowering cholesterol.

5) Impaired fasting glucose was defined as  $100 \text{ mg/dL} \leq$  fasting blood glucose  $< 126 \text{ mg/dL}$ , and diabetes was defined by fasting blood glucose  $\geq 126 \text{ mg/dL}$  or current use of anti-diabetic drugs or insulin.

6) Prehypertension was defined as  $140 \text{ mmHg} >$  systolic blood pressure  $\geq 130 \text{ mmHg}$  or  $90 \text{ mmHg} >$  diastolic blood pressure  $\geq 85 \text{ mmHg}$ , and hypertension was defined as systolic blood pressure  $\geq 140 \text{ mmHg}$  or diastolic blood pressure  $\geq 90 \text{ mmHg}$  or drug.

Variables	Periodontitis <sup>1)</sup>				P-value
	Normal		Periodontitis		
	Unweighted N	Weighted % (95% CIs)	Unweighted N	Weighted % (95% CIs)	
≥ 11	359	4.1 (3.6–4.7)	342	8.6 (7.6–9.8)	
6–10	1,225	13.9 (13.1–14.8)	961	24.7 (23.1–26.3)	
1–5	4,041	47.1 (45.9–48.4)	1,794	44.7 (43.1–46.4)	
0	3,083	34.8 (33.6–36.1)	884	21.9 (20.5–23.4)	
1) Periodontitis was defined as community periodontal index codes 3, 4					
2) Oral health care products were usually used					
3) Dental clinic visits within a year					
4) Hypercholesterolemia was defined by total cholesterol ≥ 240 mg/dL or current use of drugs for lowering cholesterol.					
5) Impaired fasting glucose was defined as 100 mg/dL ≤ fasting blood glucose < 126 mg/dL, and diabetes was defined by fasting blood glucose ≥ 126 mg/dL or current use of anti-diabetic drugs or insulin.					
6) Prehypertension was defined as 140 mmHg > systolic blood pressure ≥ 130 mmHg or 90 mmHg > diastolic blood pressure ≥ 85 mmHg, and hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or drug.					

There were many statistically significant differences in terms of the number of prosthetic crowns among the different socioeconomic status (age, income, and education), personal health practice (use of interdental brush and dental floss, and dental clinic visits), and systematic medical factors (smoking, DM, hypercholesterolemia, hypertension) groups (Table 1).

Table 2 shows the results of the hierarchical regression analyses that was used to determine the presence of a multivariable association between the number of prosthetic crowns and the prevalence of periodontal disease. The four logistic regression models were designed to adjust hierarchically for covariates. In all the models, individuals with more than six prosthetic crowns in the entire mouth were significantly different from those without any prosthetic crowns. In model 4, Compared to respondents with zero prosthetic crowns, respondents with 6–10 and ≥ 11 crowns were significantly more likely to have periodontitis (adjusted odds ratio [AOR] = 1.25, 95% confidence interval [CI] = 1.05–1.46 and AOR = 1.28, 95% CI = 1.01–1.62, respectively)

Table 2  
Multivariable association between the number of prosthetic crowns and periodontitis

Number of Prosthetic crowns	Odds ratio (95% confidence interval)			
	Model 1	Model 2	Model 3	Model 4
Total	N = 12,689	N = 12,088	N = 12,059	N = 11,406
≥ 11	<b>1.32 (1.06–1.64)</b>	<b>1.31 (1.05–1.63)</b>	<b>1.33 (1.07–1.67)</b>	<b>1.28 (1.01–1.62)</b>
6–10	<b>1.29 (1.11–1.50)</b>	<b>1.24 (1.06–1.45)</b>	<b>1.28 (1.09–1.51)</b>	<b>1.24 (1.05–1.46)</b>
1–5	1.01 (0.91–1.13)	1.02 (0.92–1.14)	1.06 (0.95–1.19)	1.02 (0.9–1.15)
0	Reference	Reference	Reference	Reference
Anterior				
≥2	<b>1.28 (1.14–1.43)</b>	<b>1.21 (1.07–1.37)</b>	<b>1.22 (1.08–1.38)</b>	<b>1.16 (1.02–1.32)</b>
0–1	Reference	Reference	Reference	Reference
Posterior				
≥ 6	<b>1.21 (1.05–1.40)</b>	<b>1.22 (1.06–1.41)</b>	<b>1.25 (1.08–1.45)</b>	<b>1.26 (1.08–1.47)</b>
4–5	<b>1.20 (1.05–1.37)</b>	1.14 (0.99–1.32)	<b>1.17 (1.02–1.35)</b>	<b>1.16 (1.00–1.35)</b>
2–3	1.03 (0.91–1.17)	1.05 (0.92–1.19)	1.08 (0.94–1.23)	1.06 (0.93–1.22)
0–1	Reference	Reference	Reference	Reference
Response variable: Periodontitis				
Explanatory variable: Number of prosthetic crowns				
Model 1 adjusted for demographic variables (sex and age)				
Model 2 adjusted for the same factors as model 1 plus socioeconomic variables (household income and level of education)				
Model 3 adjusted for the same factors as model 2 plus oral health variables (toothbrushing, interdental brushing, dental flossing, and dental clinic visits).				
Model 4 adjusted for the same factors as model 3 plus systematic medical factor variables (smoking, diabetes mellitus, hypercholesterolemia, hypertension, and body mass index).				

Results of sub-analysis by site revealed that respondents with two or more prosthetic crowns had an adjusted OR of 1.16 (95% CI 1.02–1.32) in the anterior part. In addition, periodontal disease was significantly more likely to occur in respondents with four or more prosthetic crowns in the posterior sites, 1.16 (95% CIs 1.00–1.35) was the adjusted OR in respondents with four to five prosthetic crowns and it was 1.26 (95% CIs 1.08–1.47) in respondents with six or more crowns.

Table 3 shows the results of the logistic regression analyses for multivariable associations between periodontitis and the number of prosthetic crowns after adjusting for demographic variables, socioeconomic variables, oral health variables, and systematic medical factors and stratifying by age and sex. Adjusted OR for respondents with six–ten prosthetic crowns in the entire mouth was 1.26 (95% CI 1.00–1.58) and for respondents with more than 11 crowns, it was 1.63 (95% CI 1.20–2.20) when periodontal disease was the outcome of the model. In the 19–65 years age group, there was a relationship between the number of anterior tooth prosthetic crowns and periodontal disease. In respondents with two or more crowns in the anterior site, the odds of having periodontal disease were 1.27 (95% CI 1.07–1.50). However, in the > 65 years age group, there were no significant association between the prevalence of periodontal disease and the number of anterior prosthetic crowns. In the age group of over 65 years, there was a significant association between the prevalence of periodontitis stratified by the number of prosthetic crowns in the posterior site. Respondents with more than six crowns had 1.55 (95% CI 1.20–2.00) times the odds of having periodontal disease and the respondents with 4–5 prosthetic crowns had 1.42 (95% CI 1.17–1.81) times the odds of having periodontal disease as compared to the respondents with 0–1 prosthetic crown.

Table 3

Multivariable association between the number of prosthetic crowns and periodontitis by sex and age stratification

Number of prosthetic Crowns	Odds ratio (95% confidence interval)			
	Male	Female	Age < 65 yrs	Age ≥ 65 yrs
Total	N = 4,989	N = 6,417	N = 8,859	N = 2,547
≥ 11	0.78 (0.55–1.10)	<b>1.63 (1.20–2.20)</b>	1.11 (0.76–1.61)	<b>1.48 (1.02–2.14)</b>
6–10	1.19 (0.91–1.56)	<b>1.26 (1.00–1.58)</b>	<b>1.23 (1.01–1.49)</b>	<b>1.27 (0.92–1.74)</b>
1–5	0.97 (0.82–1.15)	1.05 (0.87–1.26)	0.98 (0.86–1.12)	0.98 (0.71–1.37)
0	Reference	Reference	Reference	Reference
Anterior				
≥2	1.10 (0.92–1.32)	<b>1.21 (1.01–1.46)</b>	<b>1.27 (1.07–1.50)</b>	1.13 (0.94–1.36)
0–1	Reference	Reference	Reference	Reference
Posterior				
≥ 6	1.02 (0.78–1.34)	<b>1.42 (1.16–1.73)</b>	1.12 (0.91–1.37)	<b>1.55 (1.20–2.00)</b>
4–5	1.05 (0.83–1.32)	<b>1.26 (1.03–1.54)</b>	1.07 (0.89–1.29)	<b>1.42 (1.11–1.81)</b>
2–3	1.01 (0.84–1.22)	1.10 (0.91–1.34)	1.05 (0.90–1.24)	1.11 (0.86–1.44)
0–1	Reference	Reference	Reference	Reference
Response variable: Periodontitis				
Explanatory variable: Number of prosthetic crowns				
Models adjusted for demographic variables (sex and age), socioeconomic variables (household income and level of education), oral health variables (toothbrushing, interdental brushing, dental flossing, and dental clinic visits), and systematic medical factor variables (smoking, diabetes mellitus, hypercholesterolemia, hypertension, body mass index).				

## Discussion

The hypothesis that the shape and margin of a dental prosthesis can cause periodontal inflammation has been previously reviewed in several papers [14–17]. It is known that the fabrication process, along with the design and material of the tooth retained restoration, is associated with plaque retention and

loss of clinical attachment [18]. However, so far it is understood that if the patient can perform effective plaque control independently and with regular supportive periodontal care, optimal restoration margins within the gingival sulcus do not cause gingival inflammation [9].

In order to prevent disease of teeth with prostheses, more thorough dental care and controlling methods are needed compared to normal teeth [19–23]. In addition, periodontal disease and secondary caries can easily occur due to plaque accumulation under the prosthesis and inappropriate oral health management [24, 25, 26]. To prevent periodontal disease, various oral care products and special brushing methods are recommended according to the type of prosthesis.

Table 1 shows the ratio of the presence or absence of periodontal disease according to the number of prostheses, and it was found that there were many cases of periodontitis when 6 or more prostheses were present. In addition, the prevalence of periodontal disease increased as the number of prostheses increased in both anterior and posterior areas (Table 2).

In particular, as shown in models 3 and 4 of Table 2, despite the adjustment for the covariates of oral health behavior, systemic diseases, and demographic factors, the prevalence of periodontitis increased when number of prosthesis increased in the molar and anterior teeth. Increased periodontal disease indicates that self-oral care is not sufficient, and professional oral care is required to prevent the initiation and progression of periodontal disease associated with increased number of prostheses [27–30].

Results revealed that the disease is more likely to occur in men than in women (Table 1). Periodontal diseases are affected by various factors such as the degree of health concern, sex, hormonal factors, and oral care behavior [31–34]. The high prevalence of periodontal disease in men could reflect the difference between the aforementioned oral hygiene management ability and interest.

On the other hand, the tendency for the prevalence of periodontal disease to increase with an increase in the number of prosthetic crowns is more evident in women (Table 3). This phenomenon may be explained by a higher tendency among women to receive dental treatment as compared with men, and an increase in the prosthetic restorations may make oral hygiene maintenance more difficult. A similar tendency was seen on analyzing prosthetic treatment rate and the prevalence of periodontal disease according to health concerns [35, 36].

In the present study, in people under 65 years, the prevalence of periodontal disease was more apparent with an increase in the number of anterior prostheses than with an increase in posterior prostheses (Table 3). On the contrary, in older people, as expected, higher the number of molar prostheses, higher was the prevalence of periodontal disease.

In adults less than 65 years of age, the presence of anterior tooth prostheses is more likely to be associated with severe dental caries and poor oral hygiene [37, 38]; therefore, they have a higher probability of having periodontal disease due to insufficient plaque control. In addition, young people often undergo anterior tooth restorations to improve esthetics, and esthetics that involve placement of

crown margins deep into the gingival sulcus are an important factor in causing gingival inflammation. The results in adults aged above 65 years show that the loss of facial muscle function with increasing age likely to cause food accumulation on the buccal aspect [39, 40], thereby making the management of the lower molar prostheses difficult. In addition, the frequency of use of oral care products tends to decrease with age, making it difficult to manage oral hygiene independently, and factors such as systemic diseases may contribute to fewer visits to the dentist and thus, affect the occurrence of periodontal disease.

There are some limitations to consider when interpreting the findings of our study. First, this study has a cross-sectional design; thus, it is not possible to show causality between occurrence of periodontitis and the number of prosthetic crowns. Future population-based studies that adopt a prospective design are needed. However, cross-sectional studies such as the KNHANES may have a feasible study design, as they do not pose potential ethical issues and difficulty in observing periodontitis. Second, there is a risk of bias as the study was based on self-reported health and physical activity status. Despite these limitations, there is an advantage in the use of large-scale national datasets as it can generate results that represent the general population.

## Conclusion

In conclusion, we found that in adults, the number of prosthetic crowns is directly related to prevalence of periodontitis. Hence, people with a large number of prosthetic crowns require more specialized oral care due to restricted self-management, and this aspect needs to be explored further in future studies.

## Abbreviations

BMI: Body mass index; CPI: Community periodontal index; DM: Diabetes mellitus; IRB: Institutional review board; KCDC: Korea Centers for Disease Control and Prevention; KNHANES: Korea National Health and Nutrition Survey; WHO: World Health Organization.

## Declarations

### **Ethics approval and consent to participate:**

Written consent was obtained from all participants without ethical approval because of the national survey design (IRB No. 2018-01-03-P-A).

**Consent for publication:** Not applicable

### **Availability of data and material:**

The data from the KNHANES VII survey can be accessed and downloaded from the KNHANES homepage (URL: <https://knhanes.cdc.go.kr/knhanes/eng/index.do>).

**Competing interests:** The authors declare that they have no competing interests.

**Funding:** This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2020R1C1C1013322). The funders had no role in the study design, the analysis of the data, the preparation of the manuscript, or decision to publish.

### **Authors' contributions:**

All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: YJK, HJC. Acquisition of data: YJK, JYL. Analysis and interpretation of data: YJK, JYL. Drafting of the manuscript: YJK, JYL, HJC. Critical revision of the manuscript: YJK, YK, HJC. Statistical analysis: JYL, HJC. Administrative, technical, or material support: YK, HJC.

**Acknowledgements:** This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2020R1C1C1013322).

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