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Oral health status of Korean adults with implants according to their use of oral hygiene products: results from a nationwide population-based study (2013–2015)

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ABSTRACT

Purpose: Many home care treatments can be used to promote the health and longevity of dental implants; however, few studies are available to support the concept that self-performed oral hygiene behaviors are an essential tool for improving and maintaining oral health. We investigated age-stratified associations between dental health behaviors related to tooth brushing (TB) and oral hygiene product use in Korean adults with implants.
Methods: A total of 1,911 subjects over 19 years of age who had 1 or more implants and who participated in the 2013 to 2015 Korea National Health and Nutrition Examination Survey were reviewed. Periodontal status was assessed using Community Periodontal Index (CPI) scores, and periodontitis was defined as a CPI greater than or equal to 3. The complex sampling design of the survey was utilized to obtain the variance and individual weight of each analyzed factor. A high CPI was the outcome variable, and the main explanatory variables were oral hygiene behaviors, such as TB, dental floss (DF), interproximal brushing, and mouth rinsing.
Results: Almost all individuals with a lower CPI brushed their teeth twice or more per day, in contrast to those with a higher CPI, and were likely to use DF. The adjusted odds ratio of not using DF for a higher CPI was 1.83 (95% confidence interval, 1.35–2.49).
Conclusions: TB was implemented more than twice a day by patients with good oral health, and the combination of TB and DF significantly reduced the prevalence of a higher CPI. Self-performed oral hygiene practices combining TB and DF were significantly related to a low prevalence of periodontitis in implant patients.

Keywords: Dental devices; Dental implant; Epidemiology; Home care; Periodontitis

INTRODUCTION

There are many causes of tooth loss, including periodontal disease, dental caries, and accidents [1]. To maintain oral health, missing teeth and surrounding tissues should be replaced with artificial substitutes to restore and maintain the function, shape, and appearance of the oral cavity. In recent years, advances have been made in prostheses with

Conflict of Interest
No potential conflict of interest relevant to this article was reported.

the rise of implants. Dental implants, which are commonly used to repair missing teeth, serve as long-term replacements that preserve adjacent teeth. Dental implants can improve one's appearance, self-confidence, and self-esteem, preserve the remaining teeth, improve one's ability to speak and masticate properly, and eliminate the need for complete and partial dentures [2,3]. The size of the global dental implant industry reached $3.77 billion in 2016, exceeding forecasts by 7.7% [4]. As such, the demand for implants and the application of dental implants in various fields are increasing [5]. In particular, in light of the rapid spread of dental implants in Korea, implants for up to 2 molars for senior citizens (aged 65 and older) are covered by national health insurance, increasing the frequency of treatment. As a result, dental implant treatments comprise 30% to 50% of all prosthetic procedures [6].

Many cases of implant failure have occurred due to a lack of knowledge on the management of prostheses [7]. There are several ways for people with implants to maintain good oral health, but the primary cause of problems with implants are microorganisms derived from dental biofilms. Many studies have shown that bacterial communities in the form of bacterial membranes, such as biofilms, play an important role in the development and progression of periodontal disease, including peri-implant disease [8-11].

The formation of dental plaque biofilms around the implant is correlated with increased alveolar bone loss. The tissue around a dental implant responds to bacteria similarly to tissue around the natural teeth [12]. In fact, dental biofilms develop faster and more rapidly around titanium implant abutments than around natural teeth [13]. It is therefore essential to understand the role of oral hygiene as a key component of dental implant success [14].

Many home care treatments can be used to promote the health and longevity of dental implants, but tooth brushing (TB), the most basic preventive action to remove dental biofilm, is the most important form of oral hygiene control. Additional regular oral examinations and the use of oral hygiene products and supplemental oral hygiene products also have a significant impact on the long-term status of dental implants. Moreover, in previous studies, implant patients who used oral hygiene products to a greater extent reported higher levels of satisfaction with the implants [7]. People who have implants require more thorough oral hygiene management than those who do not; however, training in oral health behaviors for implant prosthesis management is markedly lacking.

In addition, little evidence is available to support the concept that self-performed oral hygiene behaviors are an essential tool for improving and maintaining good oral health. Therefore, we investigated age-stratified associations between oral hygiene behaviors related to TB and periodontal health in people with implants. The interaction effects of the use of oral hygiene products on periodontal health was also evaluated.

MATERIALS AND METHODS

Study design and subject selection

The data were derived from the sixth Korean National Health and Nutrition Examination Survey (KNHANES), which was conducted by the Korean Centers for Disease Control and Prevention (KCDC) from 2013 to 2015. The KNHANES was approved by the Institutional Review Board of the KCDC (2013-07CON-03-4C, 2013-12EXP-03-5C, and 2015-01-02-6C). The Korean Ministry of Health and Welfare carried out the survey, employing a complex, stratified, multistage,

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and probability-based sampling design with proportional allocation [15]. The survey's target population included all noninstitutionalized civilians in Korea aged 1 year and older. The survey used stratified multistage probability sampling units based on geographical region, sex, and age. These sampling units were based on the households reported to the National Census Registry in 2005. The 2005 census data were used, with 200 primary sampling units selected nationwide. The final sample of the KNHANES included 4,600 households. In the KNHANES, physical and oral examinations, as well as blood sampling, were conducted in mobile examination centers, where trained personnel performed all clinical measurements. The KNHANES included a highly structured health questionnaire. Each participant signed an informed consent form before participating in the survey. Previous publications of the KNHANES have detailed the sampling methods and investigations [16]. A total of 22,948 participants over 1 year of age participated in the 2013 to 2015 KNHANES survey; among these participants, 1,911 individuals over 19 years of age who had at least 1 implant were eligible to participate in this study. This survey excluded participants who did not complete an oral examination and subjects with 1 or more missing answers on their questionnaire. All variables considered in the study were analyzed, except for any missing variables.

Assessment of periodontitis

Participants' periodontal status was evaluated by trained dentists, who conducted clinical examinations while patients sat in a dental chair using a light, a mouth mirror, and a World Health Organization (WHO) periodontal probe. The WHO Community Periodontal Index (CPI) is an epidemiological tool developed by the WHO for evaluating periodontal status in population surveys. According to the WHO guidelines, a CPI probe with a 0.5-mm ball tip was utilized with a probing force of approximately 20 g. Periodontitis was defined as a CPI score greater than or equal to 3, which indicated that at least 1 site had a periodontal pocket depth (PPD) >3.5 mm (a score of 4 indicated a pocket >5.5 mm). The index tooth numbers were 11, 16, 17, 26, 27, 31, 36, 37, 46, and 47 according to the Fédération Dentaire Internationale system. If no index teeth were present in a sextant that was examined, all the remaining teeth were probed, and the highest score was recorded as the score for that sextant. In this study, the CPI was not analyzed for teeth that had implants, but the overall CPI of participants with at least 1 implant was checked. The CPI scores for periodontal health status were as follows: 0 (healthy), 1 (gingivitis with bleeding on probing), 2 (presence of calculus), 3 (PPD ≥3.5 mm), and 4 (PPD ≥5.5 mm). The highest score was recorded as the CPI score for each sextant. Participants were grouped into the following 2 categories according to their periodontal status: lower CPI (CPI of 0 to 2) and higher CPI (CPI of 3 to 4). The interexaminer reliability (mean kappa value) was 0.84.

Assessment of oral health status and behaviors

The oral health behaviors included the following: frequency of daily TB; use of dental floss (DF), use of an interproximal brush (IPB), and use of mouth rinse (MR); dental clinic visits; chewing problems; and perceived oral health status. The TB frequency per day was evaluated using questionnaires in an interview format, and participants were categorized into 2 groups (0–1 or ≥2 times per day). To investigate the use of other oral health care products, participants were asked “Have you used any other oral health care products for your oral health besides TB?” The use of DF, an IPB, and MR were dichotomized into “yes” or “no” responses. Dental clinic visits during the past year were also dichotomized into “yes” or “no” responses. To evaluate chewing problems, participants were asked “Are you uncomfortable with chewing food due to problems in your mouth, such as teeth, dentures, and gingiva?” Responses were categorized as “yes” for those who had said they were very uncomfortable or uncomfortable, and the remaining responses were categorized as “no.” Perceived oral health status was categorized as good, ordinary, or bad.

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Assessment of potential confounders

Potential confounders included sociodemographic factors (age, sex, household income, and education), general health-related behaviors (smoking status and alcohol consumption), and systemic health factors (perceived health status, hypertension, and diabetes mellitus). Sociodemographic and general health-related behaviors were collected using the standardized self-questionnaire through face-to-face interviews. General health-related factors were assessed using questionnaires, clinical examinations, and laboratory procedures involving blood tests. Participants were classified into the following 3 age groups: 19–39, 40–59, and over 60 years old. Monthly household income was categorized into 4 quartiles (<25%, 25%–50%, 50%–75%, and >75%), adjusting for the number of family members. According to the highest diploma level, participants were classified into the following 4 groups: primary school or less, middle school, high school, and college. The frequency of alcohol drinking and smoking was dichotomized as never versus ever in the lifetime. Participants were categorized as having or not having diabetes and hypertension. Hypertension was classified according to the Seventh Report of the Joint National Committee [17]. Diabetes was defined as having a fasting glucose level of at least 126 mg/dL or taking medication for diabetes. Perceived health was classified as good, ordinary, or bad.

Statistical analysis

Since the KNHANES was conducted with a complex sampling design with stratification, clustering and unequal weights, the complex sampling design of the survey was utilized to obtain the variance and individual weight of each analyzed factor. In addition, we performed age-stratification associations to eliminate the large-sample positive bias. A higher CPI was the outcome variable, and the main explanatory variables were TB, DF, IPB, and MR. All analyses were performed separately for each age group.

We utilized the chi-square test to analyze the characteristics of explanatory variables, using a complex sample analysis with weight application to estimate the weighted proportions (95% confidence interval [CI]) of the total sample population according to periodontal status (lower CPI and higher CPI). By applying multivariable logistic regression across age groups, adjusted odds ratios (aORs) with 95% CIs for the relationships of explanatory variables such as TB, DF, IPB, and MR with periodontitis were calculated after adjusting for sociodemographic factors (age, sex, household income, highest diploma), general health behaviors (alcohol drinking and smoking), and systemic health factors (perceived health status, hypertension, and diabetes mellitus). In addition, stratified analyses by age group were performed to reduce overestimation due to large samples.

The SPSS complex samples option was used for all statistical analyses (SPSS version 21; IBM Corp., Armonk, NY, USA) to accommodate the complex survey design, including stratified, random, and cluster sampling. A *P*value <0.05 was considered to indicate statistical significance.

RESULTS

Characteristics of the study participants

Among the 1,911 survey participants, the prevalence of a lower CPI was 62.2% and that of a higher CPI was 37.8%. In this study, almost all participants with a lower CPI brushed their teeth twice or more per day, in contrast to those with a higher CPI, and used DF and an IPB. The adults with a lower CPI status were predominantly women, had a higher income and higher educational level, were less likely to have hypertension or diabetes, and were less likely to smoke (Table 1).

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Table 1. Univariate associations of sociodemographic characteristics, general and oral health status, and systemic health status with periodontal status (CPI) (n=1,911)

Variables	No.	Lower CPI[a]	Higher CPI[b]	*P* value
Sex				<0.001
Male	839	446 (44.3)	393 (59.2)	
Female	1,072	743 (55.7)	329 (40.8)	
Age group (yr)				0.819
19–39	239	210 (25.3)	29 (5.6)	
40–59	764	464 (44.2)	300 (52.5)	
Over 60	908	515 (30.5)	393 (41.9)	
Household income quartile				<0.001
<25%	296	180 (12.7)	116 (14.4)	
25%–50%	433	269 (21.4)	164 (21.3)	
50%–75%	540	335 (29.0)	205 (28.4)	
>75%	642	405 (36.8)	237 (35.9)	
Highest diploma				<0.001
Primary school	537	314 (22.1)	223 (27.0)	
Middle school	246	138 (10.4)	108 (13.7)	
High school	604	378 (32.3)	226 (35.2)	
>University	524	359 (35.2)	165 (24.1)	
Alcohol drinking				0.231
Never	277	165 (11.7)	112 (13.8)	
Ever in lifetime	1,634	1,024 (88.3)	610 (86.2)	
Smoking				<0.001
Never	1,139	779 (60.1)	360 (45.3)	
Ever in lifetime	772	410 (39.9)	362 (54.7)	
Perceived health status				0.909
Good	540	337 (29.4)	203 (28.4)	
Ordinary	1,035	637 (54.5)	398 (54.9)	
Bad	336	215 (16.1)	121 (16.7)	
Hypertension				<0.001
No	1,353	878 (79.7)	475 (69.8)	
Yes	558	311 (20.3)	247 (30.2)	
Diabetes				<0.001
No	1,708	1,088 (93.2)	620 (88.4)	
Yes	203	101 (6.8)	102 (11.6)	
Tooth brushing (times per day)				0.268
Once or none	182	101 (8.7)	81 (10.4)	
Twice or more	1,729	1,088 (91.3)	641 (89.6)	
Use of dental flossing				<0.001
No	1,482	862 (70.4)	620 (85.6)	
Yes	429	327 (29.6)	102 (14.4)	
Use of interproximal brush				0.082
No	1,435	878 (73.1)	557 (77.6)	
Yes	476	311 (26.9)	165 (22.4)	
Use of mouth rinse				0.762
No	1,290	798 (66.5)	492 (65.8)	
Yes	621	391 (33.5)	230 (34.2)	
Dental clinic visit[c]				0.960
No	1,089	672 (55.9)	417 (56.0)	
Yes	822	517 (44.1)	305 (44.0)	
Chewing problems				<0.001
No	1,467	957 (82.2)	510 (72.5)	
Yes	444	232 (17.8)	212 (27.5)	
Perceived oral health status				<0.001
Good	229	158 (13.4)	71 (8.2)	
Ordinary	697	456 (37.0)	241 (32.9)	
Bad	985	575 (49.5)	410 (58.8)	

Values are presented as weighted percentages.
CPI: Community Periodontal Index.
[a]CPI 0–2; [b]CPI of 3 or over; [c]Dental clinic visit: experience of visiting a dental clinic during the past year.

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Table 2. Adjusted associations of oral health status and behaviors with periodontitis (higher CPI) across age groups (n=1,911)

Variables	ORs (95% CI)		
	19–39 (yr)	40–59 (yr)	60+ (yr)
Tooth brushing (times per day)			
Once or none	1.63 (0.32–8.41)	0.98 (0.54–1.78)	1.08 (0.65–1.54)
Twice or more	1	1	1
Use of dental flossing			
No	2.36 (0.97–5.71)	**2.04 (1.34–3.10)**	**1.86 (1.22–2.85)**
Yes	1	1	1
Use of interproximal brush			
No	1.73 (0.57–5.28)	1.12 (0.77–1.62)	1.18 (0.81–1.75)
Yes	1	1	1
Use of mouth rinse			
No	0.72 (0.29–1.81)	0.85 (0.62–1.16)	1.26 (0.94–1.75)
Yes	1	1	1
Dental clinic visit			
No	0.81 (0.31–2.14)	1.05 (0.76–1.45)	1.01 (0.73–1.40)
Yes	1	1	1
Chewing problem			
No	1	1	1
Yes	0.89 (0.20–3.98)	**1.48 (0.99–2.19)**	**1.49 (1.08–2.07)**
Perceived oral health status			
Good	1	1	1
Ordinary	1.30 (0.30–5.83)	**2.35 (1.16–4.76)**	1.05 (0.64–1.70)
Bad	1.38 (0.35–5.51)	**3.68 (1.91–7.10)**	1.12 (0.71–1.76)

Bold denotes statistical significance.
CPI: Community Periodontal Index, OR: odds ratio, CI: confidence interval.

Association between higher CPI and oral health status

Table 2 shows the outcomes of the logistic regression analysis between higher CPI and oral hygiene behaviors, adjusting for covariates across age groups. The frequency of TB showed no particular association with periodontitis in specific age groups or in all adults. However, those who did not use DF had an aOR for periodontitis twice that of their counterparts who used DF in the 19-29 years and 40-59 years groups (aOR, 2.36; 95% CI, 0.97–5.71 for 19–39 years; aOR, 2.04; 95% CI, 1.34–3.10 for 40–59 years; aOR, 1.86; 95% CI, 1.22–2.85 for over 60 years). In addition, chewing problems were associated with a higher likelihood of periodontitis.

Table 3 shows the outcomes of 4 logistic regression models of the relationship between higher CPI and oral hygiene behaviors that were designed to adjust for covariates in a hierarchical manner. The aOR of not using DF was 2.38 (95% CI, 2.14–2.76) in model 1, 2.05 (95% CI, 1.65–2.42) in model 2, 1.87 (95% CI, 1.38–2.54) in model 3, and 1.83 (95% CI, 1.35–2.49) in model 4.

Interaction effects among TB, DF, IPB, and MR on higher CPI

The relationships of oral hygiene behaviors with periodontitis according to the use of oral hygiene products tended to be similar across all age groups. If TB was performed only once a day, there was no significant difference in the use of other oral hygiene products, as shown in the overall results. If TB was performed twice or more per day, the combination of TB and DF significantly reduced the prevalence of a higher CPI (aOR, 0.32; 95% CI, 0.17–0.57 for TB twice a day with DF; aOR, 0.45; 95% CI, 0.22–0.93 for TB twice a day with DF and IPB; aOR, 0.37; 95% CI, 0.19–0.71 for TB twice a day with DF and MR; and aOR, 0.47; 95% CI, 0.22–0.99 for TB twice a day with DF, IPB, and MR in all participants) (Table 4).

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Table 3. Adjusted associations of oral hygiene behaviors with a higher CPI (n=1,911)

Variables	ORs (95% CI)			
	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
Tooth brushing (times per day)				
Once or none	1.15 (0.80–1.67)	1.04 (0.71–1.51)	1.00 (0.68–1.487)	1.04 (0.71–1.53)
Twice or more	1	1	1	1
Use of dental flossing				
No	**2.38 (2.14–2.76)**	**2.05 (1.65–2.42)**	1.87 (1.38–2.54)	1.83 (1.35–2.49)
Yes	1	1	1	1
Use of interproximal brush				
No	**1.18 (0.99–1.46)**	1.11 (0.83–1.47)	1.09 (0.82–1.36)	1.10 (0.82–1.47)
Yes	1	1	1	1
Use of mouth rinse				
No	0.87 (0.68–1.09)	0.83 (0.65–1.05)	0.83 (0.65–1.06)	0.83 (0.64–1.05)
Yes	1	1	1	1

Bold values denote statistical significance at $P<0.05$.
CPI: Community Periodontal Index, OR: odds ratio, CI: confidence interval.
[a]Model 1 contained unadjusted associations; [b]Model 2 was adjusted for age, sex, household income and highest diploma; [c]Model 3 was adjusted for all variables in model 2 and dental clinic visit, chewing problem, and perceived oral health status; [d]Model 4 was adjusted for all variables in model 3 and smoking status, alcohol drinking, hypertension, diabetes mellitus, and perceived health status.

Table 4. Interaction effects between TB, DF, IPB use, and MR use on higher CPI across age groups (n=1,911)

Variables	ORs (95% CI)			
	Total	19–39 years	40–59 years	60+ years
TB none or once only	1	1	1	1
TB twice only	0.98 (0.62–1.54)	1.01 (0.09–4.62)	1.02 (0.45–2.23)	1.15 (0.68–1.94)
DF with TB twice	**0.32 (0.17–0.57)**	0.53 (0.04–3.15)	**0.43 (0.26–1.16)**	**0.53 (0.34–0.89)**
DF and IPB with TB twice	**0.45 (0.22–0.93)**	**0.59 (0.23–0.81)**	**0.57 (0.38–0.82)**	**0.55 (0.35–0.86)**
DF and MR with TB twice	**0.37 (0.19–0.71)**	0.27 (0.01–5.11)	**0.56 (0.31–0.90)**	**0.41 (0.26–0.83)**
DF, IPB and MR with TB twice	**0.47 (0.22–0.99)**	**0.13 (0.01–0.65)**	**0.45 (0.26–0.79)**	0.65 (0.19–2.23)
IPB with TB twice	0.66 (0.40–1.09)	0.16 (0.01–2.54)	1.00 (0.41–2.45)	0.68 (0.36–1.28)
IPB and MR with TB twice	0.82 (0.45–1.51)	1.53 (0.10–4.93)	0.87 (0.32–2.33)	1.14 (0.51–2.52)
MR with TB twice	0.99 (0.61–1.62)	1.62 (0.14–3.68)	1.25 (0.54–2.91)	0.75 (0.41–1.36)

Bold denotes statistical significance.
TB: tooth brushing, DF: dental floss, IPB: interproximal brush, MR: mouth rinse, CPI: Community Periodontal Index, OR: odds ratio, CI: confidence interval.

DISCUSSION

In Korea, dental implants were introduced in the early 1990s and rapidly became more widespread in the 2000s. Currently, Korea has the world's highest number of dental implants per 10,000 people [5]. Our data provide clear evidence that more frequent TB with DF was associated with a lower prevalence of periodontitis. In particular, when TB was performed with DF twice or more a day, the efficacy was nearly 70%. Although few studies have evaluated the associations of oral health behaviors, including TB and DF, with periodontal outcomes in patients with implants, accurate epidemiological studies have shown that major oral health behaviors can have an important impact [18]. Therefore, these results provide substantial and valuable evidence that the frequency of TB and the use of DF can be a practical tool for improving dental health in patients with dental implants.

Although earlier studies reported no relationship between oral hygiene practices such as TB and DF and periodontitis [19], recent studies have shown that TB and DF are highly relevant to periodontal diseases [20]. Our study—in accordance with recent findings—determined that when the frequency of TB was high, the addition of other oral hygiene behaviors such as DF was more effective in reducing periodontitis. In our study, DF had the highest synergistic effect when combined with TB, resulting in a reduction of periodontitis by nearly 70%–80%. DF can remove plaque and control its accumulation [20]. Of the various anatomical structures of the tooth, it

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is most important to clean the gingival sulcus, where the most bacteria are present and where the most dental plaque accumulates [21]. Dental biofilms develop more rapidly around titanium abutments than around natural teeth; therefore, it is essential to understand that oral hygiene in the gingival sulcus is a key factor in the success of dental implants. [22]. Recent Cochrane reviews [23,24] and a meta-review [25] of studies of DF use over the past 10 years found that the evidence to prove the effects of DF is weak and very unreliable. The quality of the research was also reported to be low and highly biased [1]. Further, studies comparing DF with IPB use tended to exclude teeth/interproximal sites that were too narrow for appropriate IPB cleaning, resulting in a preference for IPB use [26]. Our study showed that for all age groups, periodontitis did not significantly decrease with the combination of TB and IPB. Overall, participants with a lower CPI showed a higher likelihood of using DF than IPB. However, individuals over 60 years used IPB more than DF, most likely because DF becomes harder to use than IPB with age. Dental caries and periodontal disease can develop as biofilm accumulates in the teeth and gingiva. When DF or other dental hygiene tools are used according to personal preferences, it is very important to understand the effectiveness of each tool and to use appropriate techniques accordingly. Unfortunately, in this study, it was not possible to analyze the side effects of DF or whether it was used correctly. However, it is believed that oral health can be maintained and improved much more effectively if the accurate use of DF is taught and implemented. It was also found that MR was much more commonly used than DF or IPB, possibly because of its relative ease of use. MR containing chlorohexidine may be effective for decreasing periodontitis [27]. DF can effectively reach all regions, except deep periodontal pockets and furcation areas. However, the use of an MR without antibacterial agents has shown no particular healing effects for periodontitis. Our study likewise found that MR use did not confer any protective effects in terms of reduced periodontitis. It is thought that the use of an anti-bacterial MR in combination with TB will have a better effect on reducing periodontitis. Therefore, older people should use oral hygiene products such as DF with an MR containing antimicrobial agents to help reduce periodontitis.

Of the confounding variables, income level was most closely related to periodontitis. Implants are more expensive than other prosthetic devices, but in Korea, the national health insurance system covers 2 implants for those aged 65 or older. Thus, patients with implants are not limited to the high-income population. It was also found that among patients with implants, lower income levels were associated with a higher prevalence of periodontitis. Smoking, hypertension, and diabetes were also found to be associated with periodontitis. Our data showed that smokers had a 1.5-fold increase in the prevalence of periodontitis. Other previous studies have similarly shown that smokers were approximately 3 times more likely to have periodontitis than nonsmokers [28]. Smoking impacts the immune response and negatively affects bone metabolism [29] and oral blood flow [30]. Smoking is thought to affect the prevalence of periodontitis to a greater extent in implant patients than in the general population. In our study, diabetes was associated with periodontitis. This finding supports those of a recent study, in which diabetes had an adverse effect on periodontitis [31].

However, there are some limitations of this study. First, the cross-sectional design of this study limits the degree to which it is possible to identify the exact causal relationship between oral health behavior and periodontitis. Furthermore, we used the CPI to assess periodontal status. The use of the CPI on representative teeth may include pseudo-pockets; therefore, the prevalence of periodontitis may have been overestimated or underestimated. However, since the measurements were made by trained dentists with high interexaminer reliability, it is thought that this possibility is extremely unlikely to pose meaningful issues. In addition, no previous studies have specifically analyzed oral hygiene behaviors in patients with implants, making it difficult to compare our results to those of other studies.

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Despite the above limitations, our research has several strengths. First, to the best of our knowledge, this is the first study to analyze oral hygiene behaviors and oral health status by age group among patients with dental implants using nationally representative and standardized data. Second, the associations were analyzed in models controlling for a variety of potential confounding factors, such as sociodemographic factors (age, sex, and monthly household income), and general health-related status and behaviors (drinking, smoking, perceived health status, diabetes, and hypertension).

Self-performed oral hygiene practices combining TB and DF were found to be significantly related to a low prevalence of periodontitis in people with implants. Therefore, oral health professionals should strongly recommend self-performed oral hygiene behaviors to promote dental health in patients with implants, as well as the use of DF together with TB. Although we were not able to accurately determine pre-use and post-use effects because our research could not reveal causality, our findings are significant because of the large sample size. Therefore, it is believed that a variety of studies on the effects of DF, including clinical trials and cohort studies, will be needed in the future to provide further evidence.

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