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The importance of using interdental cleaning devices on prevention of tooth loss in an employee population: a cross-sectional study

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Abstract

Background Tooth loss can lead to an increased risk of physical disease and a reduced quality of life. The current study investigated the association of the use of interdental cleaning devices with oral health outcomes such as tooth loss among employees as a healthier population.

Method Tooth loss was determined as the main outcome in 2017 in a company employee population ($n = 845$, average age = 47.76 years old, and 25.09% of female). Using the data of dental health examinations in the past 5-years from 2017, the years of use of interdental brushes (IDB) and dental floss (DF) were examined. The Community Periodontal Index (CPI) as of 5-years ago was also examined. The impact of years of use of IDB and DF on tooth loss was analyzed by a logistic regression model in stratifying the subjects into two groups by the maximum CPI (0–2 of CPI [< 4 mm] and 3–4 of CPI [≥ 4 mm]) in all periodontium.

Results In the group of maximum CPI < 3, a multivariate-adjusted odds ratio of the use of DF for 4–5 years on tooth loss was 0.42 versus for 0–1 year (reference). In the group of maximum CPI ≥ 3, the multivariate-adjusted odds ratio of the use of IDB for 4–5 years was 0.38 versus for 0–1 year (reference).

Conclusion A longer-term use of interdental cleaning devices could improve oral health outcomes in this population, while the impact could differ depending on the basis of periodontal status. These findings would be useful for making strategies for oral health promotion in healthier people as employees.

Keywords Tooth loss, Dental devices, Home care, Oral health

Introduction

Developing oral health-related policy is a global issue as oral diseases are a risk factor for various diseases. Periodontal disease has been reported to increase the risk of diabetes mellitus and cardiovascular disease [1, 2]. Tooth loss has been also indicated to be related to a reduced quality of life with several diseases and an increased risk of death with the poor nutritional status due to masticatory dysfunction [3, 4]. Proper oral care is thus necessary to prevent oral diseases.

It is usable to prevent periodontal disease and dental caries in daily life by removing mechanical and chemical

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biofilm [5]. Mechanical biofilm removal can be achieved by brushing and using interdental cleaning devices (ICDs) [5]. Recently, administration of probiotics such as *L. rhamnosus* and *L. plantarum* is also possible way to inhibit the growth and activity of periodontal and cariogenic pathogens [6]. A toothbrush alone is not always thought to be enough to remove dental plaque from the adjacent surfaces of teeth; ICDs are then required [7]. In the situation, anti-biofilm methodologies are of concern with a particular focus on using ICDs.

Some clinical studies have shown that using ICDs in addition to toothbrushing improves oral hygiene and reduces the incidence of periodontal disease and dental caries [8, 9]. In general, ICDs include interdental brushes (IDB) and dental floss (DF) [9]. A previous review paper showed that IDB and DF could reduce the occurrence of gingivitis, while the effectiveness of IDB was greater relative to that of DF [10]. However, it is noted that the previous reports reviewed were evaluated as having a relatively insufficient evidence due to the study limitations such as being conducted in short-term periods and/or clinical patient-limited settings.

Research in longer-term observation periods and/or healthier people is necessary to see the impact of oral care using ICDs on oral health outcomes for a widely available policy. As avoiding tooth loss is important in preventing chewing disorders and physical disease [3, 4, 11], applying such outcomes as tooth loss to research is required. Therefore, the current study aimed to investigate the association of the use of IDB and DF with tooth loss among employees as a healthier population.

Methods

Data sources and population

In the current study, available was the dataset that was previously recorded in dental health examinations for employees of a company in Japan. Basically, all employees participated annually in the examinations. The examination sites were set up at the office of company. The examinations were conducted using Komatsu Ltd.'s dental folding chairs with headrest, backrest, and footrest. The headlights made by Tokyo Metal Industry Ltd. was utilized in the examinations. Each subject was examined in a horizontal fixed position under ample light, ensuring a thorough examination. The dentist performed the dental examination, and the trained hygienist performed the periodontal examination, which ensured the inter-examiner reliability in the involvement of professionals.

The dataset was established in 2017 among the company employees ($n=845$, average age=47.76 years old, and 25.09% of female) who received the dental health examinations in the past 5-years. The subjects who had the number of teeth<4 were beforehand excluded. The variables by questionnaires such as age, sex, and smoking habits, as well as the examined variable as the Decayed, Missing and Filled teeth index (called DMFT index; described later [12]) were used based on the data in 2017. To see a basis of periodontal status, the examined variable as the Community Periodontal Index (CPI; described later [13]) as of 5-years ago was used. In addition to the years of dental visits and the average frequency of toothbrushing per day, the years of use of IDB and DF were obtained from the data by questionnaires in the past 5-years from 2017. To estimate the impact of the number of years of using IDB and DF on outcomes, the cross-sectional design that can consider the prior continuous years of oral health behaviors was applicable to the current study.

The Research Ethics Committee at Jichi Medical University approved this study. In cases of the studies using the data that were previously collected and anonymously treated, the informed consent was given in an opt-out manner according to the ethical guidelines of "Ethical Guidelines for Medical and Health Research Involving Human Subjects" in the Japanese Ministry of Health, Labor, and Welfare. In this manner, the study's content was released on the company's bulletin, and it allowed the subjects to refuse if they didn't want the use of their data.

Outcome

Missing teeth is the sum of healthy, treated, and untreated teeth, excluding wisdom teeth, and then tooth loss is recognized as the most important oral health outcome [3, 4, 11]. Thus, the main outcome was tooth loss in the current study. The loss was determined in 2017. It was defined as the presence of at least one tooth in the examinations in the past 5-years.

As the periodontal status can causatively affect that outcome, we stratified subjects into two groups by maximum CPI in all periodontium as of 5-years ago; 0–2 (the depth of periodontal pockets<4 mm) and 3–4 (the depth of periodontal pockets≥4 mm) [13]. The CPI was measured using a WHO (CPITN) probe, and maximum buccal and palatal/lingual values were recorded for each tooth according to WHO Oral Health Survey 4th edition criteria [13]. The CPI probe measured the depth of periodontal pockets; then, the CPI was examined in 56 areas on both sides of all teeth.

Independent variables and confounding factors

As independent variables, we used the years of use of IDB and DF. The subjects were checked up in the response to the question "did you use IDB and DF?" in the questionnaire for each year. The confounding factors were age, sex, smoking habits, the DMFT index, the years of dental visits, and the average frequency of toothbrushing per day. The DMFT index refers to untreated carious teeth

(D: carious teeth), missing teeth due to caries or other reasons (M: missing teeth), and treated teeth (F: filled teeth) [12]. That index uses the number of previously carious teeth to indicate oral deterioration related to caries, and diagnostic criteria are based on the WHO Oral Health Survey 5th edition [12]. In response to the question "did you visit the dentist within a year?" in the questionnaire, the year of dental visits was determined based on the answers of either "visited" or "currently visiting" clinics. The average frequency of toothbrushing per day was determined by averaging the responses to the question "how often do you brush your teeth every day?". We set these variables as confounding factors because the likelihood of an incidence depends on the oral condition [14], which is worsened by smoking [15] and improved by toothbrushing [16].

Statistical analysis

Differences between two groups were analysed by Independent-samples t-test or Pearson's chi-square test. We analyzed the association of use of IDB and DF with tooth loss by a logistic regression model. We classified the years of use of IDB and DF into three categories (0–1 year, 2–3 years, and 4–5 years). A multivariate-adjusted logistic regression model with all confounding factors was performed. All data were analyzed using the software of SPSS Version 25.0 (IBM Inc. Tokyo, Japan). P values of <0.05 were considered to indicate statistical significance.

The sample size was calculated using G*Power software with a two-sided alpha level of 0.05 and the power of 80%. When an event rate of 0.2 and an expected odds ratio of 0.5 were assumed with reference to the previous study [17], the total sample size required was estimated to be at least 526.

Results

The demographic characteristics of subjects are presented in Table 1. In two groups by the periodontal status, the group of max CPI≥3 showed a higher age, lower percentage of females, higher DMFT index, higher percentage of smokers, and more years of dental visits compared to the group of max CPI<3. The high percentage of subjects used IDB for 4–5 years in the group of max CPI≥3 compared to the group of max CPI<3. The high percentage of subjects used DF for 4–5 year in the group with max CPI<3 compared to the group of CPI≥3. The number of subjects with tooth loss was 122, and the average number of tooth loss was 0.27 in all subjects; that was 56 (28.00%) in the group of max CPI≥3, which was significantly higher than 66 (10.23%) in the group of max CPI<3.

Table 2 shows the results of a logistic regression model analysis for tooth loss. In the group of max CPI<3, a higher DMFT index was associated with tooth loss. The crude odds ratio of the use of DF for 4–5 years on tooth loss to its use for 0–1 year (reference) was 0.39 (95% CI 0.21–0.75), and the adjusted odds ratio was 0.42 (95% CI 0.21–0.83). The crude odds ratio of the use of IDB for 4–5 years on tooth loss to its use for 0–1 year (reference) was 2.88, but the adjusted odds ratio lost the significance. In the group of max CPI≥3, a higher DMFT index was associated with tooth loss. The crude odds ratio of the use of

Table 1 Demographic characteristics of subjects

Variables		All (*n* = 845)		Group of max CPI < 3 (*n* = 645)		Group of max CPI ≥ 3 (*n* = 200)		*P* value
Age (years)		47.76	± 8.94	46.47	± 8.92	51.94	± 7.68	< 0.01 [a]
Female (n [%])		212	(25.09%)	186	(28.84%)	26	(13.00%)	< 0.01 [b]
DMFT index		13.18	± 6.15	12.62	± 6.13	14.99	± 5.86	< 0.01 [a]
Smoking habit (n [%])		217	(25.68%)	145	(22.48%)	72	(36.00%)	< 0.01 [b]
Dental visits (years) [1]		3.17	± 1.67	3.02	± 1.68	3.65	± 1.56	< 0.01 [a]
Toothbrushing frequency/day [2]		2.39	± 0.75	2.42	± 0.75	2.28	± 0.74	0.02 [a]
Years of IDB use (n [%]) [3]	0–1 year	266	(31.48%)	224	(34.73%)	42	(21.00%)	< 0.01 [b]
	2–3 years	145	(17.16%)	114	(17.67%)	31	(15.50%)	
	4–5 years	434	(51.36%)	307	(47.60%)	127	(63.50%)	
Years of DF use (n [%]) [4]	0–1 year	400	(47.34%)	279	(43.26%)	121	(60.50%)	< 0.01 [b]
	2–3 years	154	(18.22%)	120	(18.60%)	34	(17.00%)	
	4–5 years	291	(34.44%)	246	(38.14%)	45	(22.50%)	
Number of subjects with lost teeth [5]		122	(14.44%)	66	(10.23%)	56	(28.00%)	< 0.01 [b]

CPI, Community Periodontal Index; DMFT, Decayed, Missing and Filled Teeth; IDB, interdental brushes; DF, dental floss

[1–5] These variables are determined as numbers of years from the data in the past 5-years

[a] Independent-samples t-test. [b] Pearson's chi-square test

Table 2 Association of each variable with the presence of tooth loss by max CPI

Variables		Crude 'odds ratio	95% CI	*P* value	Adjusted odds ratio	95% CI	*P* value
Group of max CPI < 3							
Years of IDB use [1]	0–1 year	reference			reference		
	2–3 years	1.89	(0.81 - 4.42)	0.14	1.44	(0.59 -3.47)	0.42
	4–5 years	2.88	(1.48 -5.59)	< 0.01	1.73	(0.82 -3.64)	0.15
Years of DF use [2]	0–1 year	reference			reference		
	2–3 years	0.93	(0.49 -1.78)	0.84	0.98	(0.50 -1.92)	0.95
	4–5 years	0.39	(0.21 -0.75)	< 0.01	0.42	(0.21 -0.83)	0.01
Age (years)		-			1.02	(0.99 -1.07)	0.23
Female sex		-			0.92	(0.47 -1.82)	0.82
DMFT index		-			1.08	(1.02 -1.13)	< 0.01
Smoking habit (presence)		-			1.43	(0.77 -2.68)	0.26
Years of dental visits [3]		-			1.13	(0.94 -1.35)	0.19
Toothbrushing frequency/day [4]		-			1.07	(0.73 -1.58)	0.72
Group of max CPI ≥ 3							
Years of IDB use [1]	0–1 year	reference			reference		
	2–3 years	0.95	(0.35 -2.56)	0.92	0.74	(0.24 -2.24)	0.59
	4–5 years	0.67	(0.32 -1.44)	0.31	0.38	(0.15 -0.95)	0.04
Years of DF use [2]	0–1 year	reference			reference		
	2–3 years	0.85	(0.36 -2.00)	0.71	0.83	(0.32 -2.17)	0.70
	4–5 years	0.76	(0.35 -1.67)	0.50	1.00	(0.41 -2.46)	0.99
Age (years)		-			1.03	(0.98 -1.08)	0.27
Female sex		-			1.13	(0.39 -3.24)	0.82
DMFT index		-			1.12	(1.04 -1.19)	< 0.01
Smoking habit (presence)		-			1.06	(0.50 -2.26)	0.87
Years of dental visits [3]		-			1.39	(1.05 -1.86)	0.02
Toothbrushing frequency/day [4]		-			0.80	(0.48 -1.33)	0.39

CPI, Community Periodontal Index; DMFT, Decayed, Missing and Filled Teeth; IDB, interdental brushes; DF, dental floss; CI, confidence interval

[1–4] Variables are determined as numbers of years from the data in the past 5-years

IDB for 4–5 years on tooth loss to its use for 0–1 year (reference) was 0.67 (95% CI 0.32–1.44), and the adjusted odds ratio was 0.38 (95% CI 0.15–0.95).

Discussion

This study revealed that a longer-term use of ICDs could reduce the risk of tooth loss in the employee population. We further found that the effect of ICDs types on tooth loss could also differ depending on the basis of periodontal status; that is, the use of DF in the max CPI < 3 and the use of IDB in the max CPI ≥ 3 could reduce the risk of tooth loss. Of note, this study population was company workers (average age = 47.76 years old) and had a low number of tooth loss in the past 5 years (average = 0.27) in comparison to the population in a clinical study [17], supporting evidence that this study population was healthier in comparison to diseased patients. Furthermore, given the fact that tooth loss is a health threat and preventable condition [3, 4, 11], the study findings will have an implication to assist oral health promotion using ICDs even to the healthier population.

The preventive effect of long-term, continuous use of ICDs on tooth loss, as shown in the current study, is explainable by the general knowledge as follows: because the plaque on adjacent surfaces of teeth and the cervical areas is often difficult to treat with a toothbrush alone, cleaning of such interdental areas using ICDs can inhibit the development of adjacent and root surface caries [7, 18]. As the caries chronically progresses [11, 18], the long-term use of ICDs, in addition to toothbrushing, might be effective to prevent tooth loss.

Furthermore, the different impact of use of IDB and DF on tooth loss on the basis of max CPI is of interest. The max CPI is related to the demographic characteristics including oral health behaviors [12–16] and this was also observed in Table 1. Even though we adjusted such demographic characteristics, the impact of use of IDB and DF on tooth loss remained. Particularly, in the group of max CPI < 3, the longer-term use of DF, rather than IDB, reduced the risk of tooth loss. The effective removal of plaque from the narrow spaces (interdental spaces and cervical areas) as in case of the max CPI < 3 is reported to be difficult for IDB [19], and DF may be more suitable in such a plaque care. On the other hand, in the group of max CPI ≥ 3, the longer-term use of IDB, rather than DF, reduced the risk of tooth loss. While periodontal disease (a risk factor of tooth loss) is presumable to be advanced as in case of the max CPI ≥ 3, the use of IDB is reported

to be helpful for treating with periodontal disease [20, 21]. These ideas may partly explain the current study findings. There is no consensus on whether IDB or DF is more effective because there is a lack of robust evidence [22]. Previous studies comparing the use of IDB and DF have suggested that IDB is as effective as or slightly more effective than DF [22]. However, the previous studies' limitation is that they did not adjust for the different attributes of the IDB and DF groups, such as age and sex or the level of periodontitis prior to the intervention. Our current study is significant because we stratified the subjects by CPI and made comparisons after adjusting for confounding factors by age, gender, smoking habits, the DMFT index, the years of dental attendance, and the frequency of brushing. A study that intervened and compared subjects with both IDB and DF concluded that IDB was easier to use and more effective in patients with moderate or severe periodontal disease [23], which might affirm the results of the current study.

This study has the strength that we used the record of dental health examinations in each subject to eliminate the recall bias. Nonetheless, we acknowledge several limitations associated with the study. First, as oral health habits were obtained on questionnaire, the responses may be modified by so-called a social desirability bias, which favors desirable responses [24]. Second, as the study was conducted in a single company, the results may not completely be generalizable. Finally, the other confounding factors for tooth loss, for instance food preference, were not examined. These limitations should be addressed in future studies.

Conclusions

The current study revealed that a longer-term use of ICDs could improve oral health outcomes such as tooth loss in company employees as a healthier population. Particularly, the longer-term use of DF could reduce the risk of tooth loss in shallow periodontal pockets, and the longer-term use of IDF could reduce it in deep periodontal pockets. The continuous use of an appropriate ICDs type could be recommended by max CPI. The findings will be useful for making strategies for oral health promotion in healthier people as employees.

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Author contributions
KN, MI, NT and KK contributed to the conception of the research. MI, and TY prepared the data. KN and KK designed the study and investigation. KN analyzed the data and wrote the draft manuscript. YF and KK reviewed the article. YF and KK supervised the study. All authors have read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The Research Ethics Committee approved this study (Jichi Medical University, No. 22–227). Informed consent was obtained from all subjects in an opt-out manner.

Competing interests
KN and KK did the joint research agreements with Sunstar Inc. where MI and TY worked.

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References

1. Liccardo D, Cannavo A, Spagnuolo G, Ferrara N, Cittadini A, Rengo C, et al. Periodontal Disease: a risk factor for diabetes and Cardiovascular Disease. Int J Mol Sci. 2019;20(6):1414.
2. Larvin H, Kang J, Aggarwal VR, Pavitt S, Wu J. Risk of incident cardiovascular disease in people with periodontal disease: a systematic review and meta-analysis. Clin Exp Dent Res. 2021;7(1):109–22.
3. Haag DG, Peres KG, Balasubramanian M, Brennan DS. Oral conditions and health-related quality of life: a systematic review. J Dent Res. 2017;96(8):864–74.
4. Kusama T, Takeuchi K, Kiuchi S, Aida J, Kondo K, Osaka K. Weight loss mediated the relationship between tooth loss and mortality risk. J Dent Res. 2023;102(1):45–52.
5. Claydon NC. Current concepts in toothbrushing and interdental cleaning. Periodontol 2000. 2008;48:10–22.
6. D'Agostino S, Valentini G, Iarussi F, Dolci M. Effect of Probiotics Lactobacillus rhamnosus and Lactobacillus plantarum on Caries and Periodontal diseases: a systematic review. Dent J (Basel). 2024;12(4):102.
7. Sanz M, Herrera D, Kebschull M, Chapple I, Jepsen S, Beglundh T, et al. Treatment of stage I-III periodontitis-the EFP S3 level clinical practice guideline. J Clin Periodontol. 2020;47(Suppl 22):4–60.
8. Pitchika V, Jordan R, Micheelis W, Welk A, Kocher T, Holtfreter B. Impact of Powered Toothbrush Use and Interdental cleaning on oral health. J Dent Res. 2021;100(5):487–95.
9. Ng E, Lim LP. An overview of different interdental cleaning aids and their effectiveness. Dent J (Basel). 2019;7(2):56.
10. Worthington HV, MacDonald L, Poklepovic Pericic T, Sambunjak D, Johnson TM, Imai P, et al. Home use of interdental cleaning devices, in addition to toothbrushing, for preventing and controlling periodontal diseases and dental caries. Cochrane Database Syst Rev. 2019;4(4):CD012018.
11. Suzuki S, Sugihara N, Kamijo H, Morita M, Kawato T, Tsuneishi M, et al. Reasons for tooth extractions in Japan: the second Nationwide Survey. Int Dent J. 2022;72(3):366–72.
12. World Health Organization. Oral health surveys: basic methods. 5th ed. Geneva: World Health Organization; 2013.
13. World Health Organization. Oral health surveys: basic methods. 4th ed. Geneva: World Health Organization; 1997.
14. Kinane DF, Stathopoulou PG, Papapanou PN. Periodontal diseases. Nat Rev Dis Primers. 2017;3:17038.
15. Haber J, Kent RL. Cigarette smoking in a periodontal practice. J Periodontol. 1992;63(2):100–6.
16. Attin T, Hornecker E. Tooth brushing and oral health: how frequently and when should tooth brushing be performed? Oral Health Prev Dent. 2005;3(3):135–40.
17. Giannobile WV, Braun TM, Caplis AK, Doucette-Stamm L, Duff GW, Kornman KS. Patient stratification for preventive care in dentistry. J Dent Res. 2013;92(8):694–701.
18. Takano N, Ando Y, Yoshihara A, Miyazaki H. Factors associated with root caries incidence in an elderly population. Community Dent Health. 2003;20(4):217–22.

19. Londero AB, Reiniger APP, Tavares RCR, Ferreira CM, Wikesjö UME, Kantorski KZ, et al. Efficacy of dental floss in the management of gingival health: a randomized controlled clinical trial. Clin Oral Investig. 2022;26(8):5273–80.
20. Sälzer S, Slot DE, Van der Weijden FA, Dörfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis–a meta-review. J Clin Periodontol. 2015;42(Suppl 16):S92–105.
21. Slot DE, Dörfer CE, Van der Weijden GA. The efficacy of interdental brushes on plaque and parameters of periodontal inflammation: a systematic review. Int J Dent Hyg. 2008;6(4):253–64.
22. Gallie A. Home use of interdental cleaning devices and toothbrushing and their role in disease prevention. Evid Based Dent. 2019;20(4):103–4.
23. Christou V, Timmerman MF, Van der Velden U, Van der Weijden FA. Comparison of different approaches of interdental oral hygiene: interdental brushes versus dental floss. J Periodontol. 1998;69(7):759–64.
24. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthc. 2016;9:211–7.

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