Effects of lingual site toothbrushing on periodontal disease in the elderly: a cross-sectional study

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Abstract

Background: This study aimed to evaluate the association between periodontitis and toothbrushing on the lingual surfaces of teeth (lingual toothbrushing) among community dwelling Korean elders.

Methods: A total of 150 elderly participants (34 males and 116 females) from Seoul, Korea, were cross-sectionally examined. Socio-demographic, habitual, and systemic health-related factors were analyzed. Logistic regression analysis was performed for outcomes of periodontitis.

Results: Oral health activities including lingual toothbrushing were closely correlated with oral health status. Lingual toothbrushing demonstrated a significant association with periodontitis. The odds ratio (95% confidence interval) was 8.98 (1.30-62.15) with inclusion of demographic status, systemic health status, oral health activity, and oral health status.

Conclusions: Here, we demonstrate that lingual toothbrushing is associated with periodontitis in the elderly. The importance of lingual toothbrushing should be emphasized in oral health education.

Background

The prevalence of periodontal disease in the elderly (65 years and older) is 47.6%. This oral health disorder is connected to disease burden [1, 2]. Periodontal disease is linked to the loss of multiple teeth in old age, thereby affecting overall health [3]. Oral diseases due to multiple tooth loss and poor oral health can lead to secondary health problems, impairing quality of life in old age [4]. In particular, chronic diseases such as diabetes and cardiovascular diseases, which commonly affect the elderly, are closely related to periodontal disease [5, 6]. Therefore, maintenance of oral health in the elderly is essential to facilitate improved general health and maintain a high quality of life [7, 8].

Based on data from the Korean National Statistical Office and Ministry of Health and Welfare, income inequality has persistently increased, and social polarization and inequality are major issues on the political agenda [9]. Several studies have reported socioeconomic disparities in oral health and dental service use [10–12]. As the gap in income, education, and occupations between the rich and poor has widened, oral health inequalities have become more pronounced in Korea [13]. Ensuring good oral health habits is one of the easiest and most efficient ways to alleviate these health inequities. Further, daily oral health activities are highly effective for maintaining a healthy oral status and mitigating periodontal health inequality in the elderly [14, 15]. However, oral health is one of the most neglected health domains with increasing age, especially due to social perceptions that undermine the importance of oral health for general health [16, 17]. Education on oral health activities primarily focuses on techniques of toothbrushing; however, studies on optimal brushing techniques are limited [18]. Dental calculus, which is the main cause of periodontal disease, is most frequently observed on the lingual surfaces of the lower teeth. Therefore, lingual toothbrushing is crucial to prevent the deposition of calculus [19].
This study was aimed that oral health activities including lingual toothbrushing performed by elderly individuals were measured using an objective evaluation tool for oral health status, and measured impact of lingual toothbrushing on periodontal disease in this cohort.

**Methods**

**Study design**

This cross-sectional study was approved by the institutional research ethics committee of Seoul National University (IRB NO, S-D2019020). Written informed consent was obtained from each participant. The study was conducted from October 2019 to March 2020 (duration of 6 months), targeting an elderly group aged 65 years and over. Trained researchers conducted a questionnaire via face-to-face interviews with elderly participants for approximately 20 minutes. The questionnaire contents evaluated the socio-economic factors, general health status, and oral health activities of the elderly group, followed by direct investigation of the oral health status of the participants by two dentists.

**Populations**

In this study, 150 elders were selected from Seoul, Korea, as study subjects. The population aged 65 years and above were included. Subjects were excluded if they faced difficulties completing the questionnaire or if evaluation of their oral health condition by dentists was challenging. The sample size was estimated based on the latest national oral health survey performed on 2017, when the prevalence of periodontitis of elderly (over 65 year-olds) in Korea was 47.6%. We set the width of the 95% confidence interval at 10% when considering the questionnaire response and drop out rate 30%. At least 150 elderly had to be recruited.

**Clinical examinations**

Examinations were performed using a portable dental unit equipped with a dental light, oral mirror, and periodontal probe. To assess oral health, an oral examination was performed by trained dentists using the WHO oral health survey protocol [20]. A whole-mouth periodontal examination was conducted by the dentist using a periodontal probe (Hu-Friedy PCP-UNC 15, Hu-Friedy, Chicago, IL, USA). The periodontal pocket depth (PD) was measured at whole sites for each tooth (mesio-labial, mid-labial, disto-labial, mesio-lingual, mid-lingual, and disto-lingual) as the distance from the gingival margin to the bottom of the sulcus. Bleeding on probing (BOP) was measured at the edge of the gum surrounding each tooth, divided into the central, lingual, and mesial sides. Based on observations of whether bleeding occurred at these sites, the arithmetic mean of BOP was calculated.

The repetitive saliva swallowing test (RSST), which is often used as a screening test of swallowing function, was employed in this study. The participants were instructed to sit in a relaxed position and perform repetitive voluntary swallowing as quickly as possible for 30 s. The number of swallows was counted and used as the RSST score [21].
Masticatory Performance Evaluating gum XYLITOL® (30 mm × 20 mm × 1 mm, 3.0 g) was obtained from LOTTE Co., Ltd. The participants were instructed to masticate the gum continuously for 3 min on the usual occluding side at a rate of approximately one stroke per second. After each trial, the chewed gum bolus was placed between two glass plates and pressed to approximately 1 mm thickness. It was then covered by a clear film with 2 mm square marks. The color within each square was classified into two categories: presence of chewing difficulties (green, yellow, light pink) or absence of chewing difficulties (pink and red) [22].

Oral moisture was measured at the lingual mucosa (LM; the surface of the tongue 10 mm from the apex linguae) using an oral-moisture checking device (Mucus1, Life Co., Saitama, Japan) by instructing the participants to stick out their tongue [23].

**Oral health activity**

Sugar and acidic food-eating behaviors were divided into two groups: one group that provided a history of intake of these foods more than three times per day and another group that provided a history of intake of these foods less than thrice daily. Participants were instructed to complete a questionnaire regarding oral health foods including fresh seasonal vegetable intake. Via a face-to-face questionnaire, various factors were assessed, such as the daily frequency of toothbrushing, need for help during brushing, inclusion of lingual surfaces in toothbrushing, and use of an interdental brush and fluoride toothpaste during the toothbrushing technique.

**Assessment of confounders**

Demographic factors considered in the present study included age, sex, education status, house income, health insurance, and co-residence status. Other factors considered in the study were activities of daily life of the participants, smoking habits, and history of systemic diseases, including diabetes and cardiovascular diseases. This information was collected via direct questioning of the study participants. Several health-related confounders were also considered in the study, including hand grip strength, arm circumference, and calf circumference.

Hand grip strength was measured using digital equipment (TKK K401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). At the thigh level, grip strength was measured with the forearm away from the body. Participants were instructed to apply maximum grip strength three times with their left and right hands. Between each measurement, a rest interval of at least 30 s was allowed. Grip strength was defined as the maximum measured grip strength of the dominant hand [24]. A point midway between the tip of the acromion process of the scapula and olecranon process was marked with the participant's arm flexed at 90°; this point was used to calculate mid-arm circumference to the nearest 0.1 cm [25]. Calf circumference was measured using a measuring tape at the maximum circumference of the non-dominant leg in a sitting position with the leg bent 90° at the knee [26].

**Statistical analysis**
Characteristics are described using frequency distributions for categorical variables and mean values with standard deviations for continuous variables. The differences between categorical variables and normally distributed continuous variables were compared using chi-square tests and t-tests, respectively. Separate odds ratios (ORs) and 95% confidence intervals (CIs) were computed to quantify the association between the disabled and non-disabled. To quantify the association with oral health outcomes and socioeconomic status, the analysis was restricted using the SPSS statistics program (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, USA).

Results

The cohort derivation is summarized in Table 1. We assessed whether internal toothbrushing was performed according to explanatory variables and covariates. No significant differences were observed in gender, age, health insurance, living alone, presence of systemic diseases, smoking, eating sweet foods, use of fluoride toothpaste, and the inconvenience of swallowing between the study groups. Of the study participants, those who practiced lingual tooth brushing presented with higher household income and superior education when compared to those who did not. Activities of daily living and grip strength for arm circumference were superior in the group that performed lingual site toothbrushing. Lower calf circumference was more common in the group who performed lingual toothbrushing. Factors such as vegetable intake, toothbrushing frequency, need for help during toothbrushing, and use of interdental brushes were higher in the group that performed lingual toothbrushing. High number of teeth, low decayed, missing and filled permanent teeth (DMFT), and low prevalence of periodontal disease were noted among participants who performed lingual toothbrushing. Based on oral health condition, low BOP rate, low swallowing inconvenience rate, and high oral moisture value were noted in the group that performed lingual brushing (Table 1).
| Characteristics of participants according to lingual site toothbrushing | Not performed | Performed | p-value |
|---------------------------------------------------------------|--------------|-----------|---------|
| **Lingual site toothbrushing**                                |              |           |         |
| **Sex**                                                       |              |           |         |
| Male                                                          | 13           | 20.0%     | 21      | 24.7% | 0.495 |
| Female                                                        | 52           | 80.0%     | 64      | 75.3% |
| **Age**                                                       | 80.17 ± 6.84 | 78.49 ± 7.39 | 0.158 |
| **Income**                                                    |              |           |         |
| Q1                                                            | 43           | 66.2%     | 39      | 45.9% | 0.012 |
| Q2                                                            | 18           | 27.7%     | 26      | 30.6% |
| Q3                                                            | 3            | 4.6%      | 17      | 20.0% |
| Q4                                                            | 1            | 1.5%      | 3       | 3.5%  |
| **Education**                                                 |              |           |         |
| Less than elementary school                                   | 8            | 12.3%     | 30      | 35.3% | 0.003 |
| Middle school                                                 | 38           | 58.5%     | 28      | 32.9% |
| High school                                                   | 10           | 15.4%     | 10      | 11.8% |
| College                                                       | 9            | 13.8%     | 17      | 20.0% |
| **Health insurance**                                          |              |           |         |
| Medical aid                                                   | 5            | 7.7%      | 7       | 8.2%  | 0.903 |
| National health insurance                                     | 60           | 92.3%     | 78      | 91.8% |
| **Coresidence status**                                        |              |           |         |
| With family                                                   | 62           | 95.4%     | 81      | 95.3% | 1.000 |
| Living alone                                                  | 3            | 4.6%      | 4       | 4.7%  |
| **Activities of daily living**                                |              |           |         |
| Independent                                                   | 34           | 52.3%     | 71      | 83.5% | 0.000 |
| Dependent                                                     | 31           | 47.7%     | 14      | 16.5% |
| **Systematic diseases**                                       |              |           |         |
| Absence                                                       | 1            | 1.5%      | 4       | 4.7%  | 0.389 |
| Presence                                                      | 64           | 98.5%     | 81      | 95.3% |
| **Smoking**                                                   |              |           |         |
| Non-smoker                                                    | 59           | 90.8%     | 78      | 91.8% | 0.830 |
| Smoker                                                        | 6            | 9.2%      | 7       | 8.2%  |
| **Grip strength (M ± SD)**                                    | 12.9 ± 7.3   | 17.4 ± 6.8 | 0.000 |
| **Arm circumference (M ± SD)**                                 | 26.4 ± 3.1   | 28.0 ± 2.2 | 0.001 |

DMFT, decayed and missing and filled tooth; BOP, bleeding on probing.
|                                      | Lingual site toothbrushing                  |
|--------------------------------------|--------------------------------------------|
|                                      | 28.70 ± 3.28 27.29 ± 4.44  0.027           |
| Calf circumference (M ± SD)           |                                            |
|                                      | 28.70 ± 3.28 27.29 ± 4.44  0.027           |
| Sugary and acidic food               |                                            |
|                                      | 26  40.0%  44  51.8%  0.152                |
|                                      | 39  60.0%  41  48.2%                        |
|                                      |                                            |
| Seasonal fresh vegetables            |                                            |
|                                      | Never                                      |
|                                      | 14  21.5%  6  7.1%  0.001                  |
|                                      | Once a week                                |
|                                      | 21  32.3%  16  18.8%                      |
|                                      | Once a day                                 |
|                                      | 30  46.2%  63  74.1%                      |
|                                      |                                            |
| Number of times of toothbrushing     |                                            |
|                                      | ≥ 2 times                                  |
|                                      | 14  21.5%  4  4.7%  0.002                  |
|                                      | ≥ 2 times                                  |
|                                      | 51  78.5%  81  95.3%                      |
|                                      |                                            |
| Needed support for toothbrushing     |                                            |
|                                      | Independent                                |
|                                      | 45  69.2%  80  94.1%  0.000                |
|                                      | Need support                              |
|                                      | 20  30.8%  5  5.9%                        |
|                                      |                                            |
| Interdental brush                   |                                            |
|                                      | Non-user                                  |
|                                      | 56  86.2%  44  51.8%  0.000                |
|                                      | User                                      |
|                                      | 9  13.8%  41  48.2%                      |
|                                      |                                            |
| Fluoride toothpaste                  |                                            |
|                                      | Non-user                                  |
|                                      | 22  33.8%  22  25.9%  0.288                |
|                                      | User                                      |
|                                      | 43  66.2%  63  74.1%                      |
|                                      |                                            |
| Remaining teeth (M ± SD)             |                                            |
|                                      | 14.02 ± 6.12  20.16 ± 5.78  0.000          |
| DMFT (M ± SD)                        |                                            |
|                                      | 14.22 ± 5.17  10.59 ± 5.82  0.000          |
| Periodontitis                        |                                            |
|                                      | Non-periodontitis                         |
|                                      | 25  38.5%  69  81.2%  0.000                |
|                                      | Periodontitis                             |
|                                      | 40  61.5%  16  18.8%                      |
|                                      |                                            |
| BOP RATE (M ± SD)                    |                                            |
|                                      | 68.8% ± 18.6%  21.1% ± 18.7%  0.000        |
| Swallowing difficulties              |                                            |
|                                      | Absent                                    |
|                                      | 53  81.5%  77  90.6%  0.106                |
|                                      | Present                                   |
|                                      | 12  18.5%  8  9.4%                         |
| Chewing difficulties                 |                                            |
|                                      | Absent                                    |
|                                      | 21  32.3%  48  56.5%  0.003                |
|                                      | Present                                   |
|                                      | 44  67.7%  37  43.5%                      |
| Oral moisture value (M ± SD)         |                                            |
|                                      | 19.86 ± 5.24  23.68 ± 4.44  0.000          |
| DMFT, decayed and missing and filled tooth; BOP, bleeding on probing. | 

Analyses of the effects of interaction between oral health activity and oral health status revealed positive correlation between sugar and acidic food intake frequency and DMFT. We observed a positive
correlation between seasonal fresh vegetable intake and the number of existing teeth as well as negative correlation with BOP rate and periodontal disease prevalence. Daily toothbrushing frequency have negative correlation with BOP rate, presence of periodontal disease, and using an interdental brush were positively correlated with the number of remaining teeth, and negatively correlated with BOP rate, and presence of periodontal disease. A negative correlation was noted between the use of fluoridated toothpaste, BOP rate, and periodontal disease prevalence (Table 2).

|                              | Number of remaining teeth | DMFT   | BOP rate | Periodontitis |
|------------------------------|---------------------------|--------|----------|---------------|
| Sugary and acidic food intake (over 3 times) | -.115                     | .165* | .053     | .004          |
| Fresh seasonal vegetable intake (over once a week) | .193*                     | -.064 | -.373**  | -.267**       |
| Number of times of toothbrushing (over 2 times) | .134                      | -.137 | -.242**  | -.182*        |
| Help needed for toothbrushing | -.230**                   | .203* | .450**   | .431**        |
| Using of interdental brush   | .246**                    | -.140 | -.373**  | -.253**       |
| Using of fluoride toothpaste | .138                      | -.012 | -.330**  | -.195*        |
| Lingual site toothbrushing   | .448**                    | -.330** | -.785**  | -.438**   |

*p-value < 0.05 **p-value < 0.01. DMFT, decayed and missing and filled tooth; BOP, bleeding on probing.

After adjustment, lack of performance of lingual toothbrushing in models 1–5 were associated with periodontitis prevalence (Table 2). Our data in Model 5 revealed that participants with a high frequency of lingual site toothbrushing exhibited a lower prevalence of periodontitis than did those with low frequency of lingual site toothbrushing (adjusted OR: 8.98; 95% CI: 1.30-62.15, Table 3).
Table 3
Multivariable association between lingual site toothbrushing and periodontitis

|                        | Model 1       | Model 2       | Model 3       | Model 4       | Model 5       |
|------------------------|---------------|---------------|---------------|---------------|---------------|
| Lingual site toothbrushing | Not performed | 7.28 (3.42–15.5) | 7.01 (3.02–16.3) | 8.21 (2.77–24.36) | 8.95 (2.51–31.94) | 8.98 (1.30–62.15) |
| Performed              | Reference     | Reference     | Reference     | Reference     | Reference     | Reference     |

Model 1: age, sex

Model 2: demographic status (age, sex, income, education, health insurance, coresidence status)

Model 3: demographic status, systematic health status (activities of daily living, systematic disease, smoking, grip strength, arm circumference, calf circumference)

Model 4: demographic status, systematic health status, oral health activity (vegetable intake, number of times of toothbrushing, help needed for toothbrushing, using of interdental brush, using of fluoride toothpaste)

Model 5: demographic status, systematic health status, oral health activity, oral health status (remaining teeth, DMFT, bleeding on probing rate, swallowing difficult, chewing difficult, oral moisture)

Discussion

This cross-sectional study demonstrated that lingual site toothbrushing was associated with periodontitis in elderly Koreans. Although developments in dental technology have slowed the rate of deterioration of oral health, it is critical for individuals to continue to care and manage oral health prior to treatment [27–29]. Poor oral health can result in exacerbations of systemic diseases and significantly impact involuntary weight loss and aging [30, 31]. Therefore, maintaining and managing oral health in the elderly is essential. In this study, we confirmed various health conditions and activities, such as information on the oral health condition of the elderly, oral health activity, and general health condition associated with oral health behavior. The use of an internal toothbrush was directly associated with health (Table 1). According to previous research, greater oral health awareness was associated with superior oral health care behaviors [32–34]. Positive oral health activities such as using oral care products and regular toothbrushing reduce the risk of behavior-associated health issues [35–37].

Certain oral health activities are closely associated with oral health. For instance, fresh vegetable intake promotes oral nutritional balance, and antioxidants in the diet have benefits and valuable properties contribute to the maintenance of periodontal health [37]. Poor nutrition is associated with poor oral health in the elderly.

Elderly individuals who are aging, have low activities of daily life (ADL), or need help with brushing have higher levels of halitosis [38]. Al-Zahrani et al. [39] reported a relationship between physical activity and the prevalence of periodontitis. A national survey in America reported that a high level of physical activity prevented periodontitis. Indeed, physical activity was positively associated with antibodies in the orange
and blue complex related to healthy periodontal states [40]. In addition, it has been reported that periodontal disease often occurs in elderly individuals with poor health activities and conditions [41].

The use of fluorine in periodontal disease has no known direct effects on periodontal disease [42]. The use of fluoride toothpaste should be considered an area worthy of examination for oral health concerns to establish a link between oral health and components of toothpaste [43].

A systematic review suggested that interdental cleansing, such as the use of an interdental brush, should be performed in parallel rather than in isolation as an effective means of reducing periodontal disease and plaque index [44]. This procedure also revealed the effects of alleviating periodontal health inequalities and is an important tool for maintaining oral health [45]. This study clarified that these oral health states and behaviors are related to each other and exhibited similar tendencies to those reported previously (Table 2).

Periodontal disease is caused by dental plaques. A common site of occurrence of dental plaques in adults and the elderly is the snow surface of the lower anterior tooth [46]. It is thus crucial to brush the inner surface due to frequent periodontal disease caused by calculus on the inner surface of the teeth [48]. Further, our study suggested that individuals lacking proper oral health education tend not to clean the inner surface of teeth. Thus, it is important to direct the bristles vertically toward the tooth surface for effective plaque removal. In addition, knowledge related to good dental health is necessary to perform effective toothbrushing [47]. To gain evidence for brushing education, high quality research is required to provide more definitive guidelines on oral health promotion practices for the elderly [48].

In this study, after correcting for sociological factors, medial tooth brushing strongly influenced periodontal disease in the elderly (8.98 times higher than in subjects without medial tooth brushing). Further, we clarified that inner brushing execution is not effective in those with relatively weak grip strength or those who are dependent on others for daily life activities or execution of brushing (Table 1). The recognition and emphasis of the importance of internal tooth brushing when help is required are crucial.

**Strengths of the study**

The present study considered a variety of health status criteria, including oral health status in the elderly, measured via health measurement devices. The study is also supported by related research on toothbrushing as a well-established risk factor for periodontal disease. Although the exact effects of lingual site brushing are not understood, it should be considered a major contributor to periodontal disease.

**Limitations of the study**

Further studies are needed to elucidate causality and biological mechanisms, and render valid estimates with minimal bias. This cross-sectional study don’t clarified the casualty but the prevalence of the association between periodontitis and oral health activities, including brushing the lingual area. Studies
that include biomarker information and demographic factors will further clarify the biological mechanisms and social impact of the link between periodontitis and oral health activities. Future studies that are more representative of the general population with larger sample sizes will permit stratified analysis to detect factors that reduce selection bias and correct the effects of periodontitis on lingual brushing performance. Despite these limitations, the results of the current study shed insight into the association between periodontitis and lingual site toothbrushing in an elderly cohort of Koreans.

Conclusions

Overall, the results of this study demonstrated that periodontitis is independently associated with lingual site toothbrushing after controlling for various confounders such as demographic status, systemic health status, oral health activity, and oral health status. Our data suggest that dental health professionals should pay attention to the link between periodontal health and lingual site toothbrushing.

List Of Abbreviations

CPITN: community periodontal index of treatment needs
RSST: repetitive saliva swallowing test
BOP: bleeding on probing
DMFT: decayed and missing and filled permanent teeth
ADL: activities of daily living

Declarations

Ethics approval and consent to participate: Written consent was obtained from all subjects with ethical approval (IRB No. S-D20190020).

Consent for publication: Not applicable

Availability of data and material: The database used in this study includes clinical data collected prospectively from consented volunteers and patients. This database contains protected health information and, by ethical approval, has not been made publicly available.

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

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Authors’ contributions: All authors contributed to this paper. YBI and JYL performed the data analysis and wrote the entire manuscript. JYL participated in the study design, revised the manuscript, and implemented the literature study. YBI searched and elaborated on previous studies on oral health
activities. BHJ coordinated the study and helped to draft the manuscript. All authors participated in the final manuscript.

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