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Impact of Unreplaced Lost Teeth on Blood Pressure: An Evaluation of Health Checkup Data

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Abstract

Although positive relationships between tooth loss and cardiovascular disease have been extensively reported, the impact of tooth loss left unreplaced for a certain period on cardiometabolic conditions remains unclear. Thus, we aimed to evaluate the effects of unreplaced tooth loss with cardiometabolic markers in middle-aged bankers using data obtained from health checkups conducted at 2 age points with a 4-year interval. A total of 218 bankers aged 46 years with unreplaced teeth after loss 4 years prior (at age of 42 years) were analyzed. The health checkup included a physical examination, collection of blood specimen for laboratory test, a self-administered questionnaire regarding health behaviors, and a dental examination. Participants were categorized into 2 groups; those who had unreplaced tooth loss (UTL) and those who did not. Differences in mean values for systolic and diastolic blood pressure, high-density lipoprotein cholesterol and triglycerides, fasting blood glucose, and HbA1c between the groups were evaluated using analysis of covariance. A logistic regression model was constructed to calculate the odds ratio of the relation of UTL with high blood pressure (BP) (systolic BP ≥130 mmHg and/or diastolic BP ≥85 mmHg) including covariates. We found that higher levels of both systolic and diastolic BP were observed in participants with UTL than in those without (123.4 vs. 119.4 mmHg, and 75.9 vs. 71.9 mmHg, respectively), with a statistical significance in mean value for diastolic BP ($P<0.01$). In addition, participants with UTL had greater odds for high blood pressure, after adjusting for the covariates (adjusted odds ratio = 2.58 [1.25-5.35]). While, there were no significant differences in regard to the mean values for high-density lipoprotein cholesterol, triglycerides, fasting blood glucose, and HbA1c between the groups. Our results suggest that tooth loss left unreplaced for a certain period is related to increased BP levels in this early middle-aged population.

Introduction

Tooth loss is the final consequence of periodontal disease and dental caries. Numerous epidemiological studies have demonstrated a positive relationship between tooth loss and cardiovascular disease [1-4], as well as various cardio-metabolic risk factors such as obesity [5], hypertension [6], and metabolic syndrome [7]. Chewing difficulties and oral function imbalances caused by lost teeth lead to alterations in food selection and consumption [8-10], and the digestive process [11], which have been proposed to be related to the link between tooth loss and cardiovascular disease [12,13]. On the other hand, lost teeth can be replaced with removable or fixed dental prostheses, helping to improve oral function [14].

Although a recent study showed that the number of unreplaced teeth was associated with increased risk for cardiovascular mortality [15], the impact of tooth loss left unreplaced over time on cardiometabolic conditions was not examined. Thus, we hypothesized that individuals with unreplaced tooth loss (UTL) have worse cardiometabolic conditions such as high blood pressure (BP), glucose, and lipid metabolism disorder as compared to those without, and that a certain period of time is needed before the effect of UTL on cardio-metabolic conditions appears in clinical findings.

To test our hypothesis, a long-term randomized clinical trial in which individuals with lost teeth are randomly assigned to a "replacement treatment" group or a "no treatment" group would be ideal. However, such studies are difficult to conduct based on ethical perspective. Thus, we obtained data from health checkups conducted at 2 age points with a 4-year interval, and evaluated the effects of UTL on cardiometabolic markers in middle-aged bankers.

Materials and Methods

The present study was a continuation of our previous work [16], which was performed using secondary data obtained from health checkups conducted at a large bank company in Japan. Although the Industrial Safety and Health Law of Japan require employers to provide annual medical checkups to employees, dental checkups are not required by the law. Bankers of the present company were eligible to receive dental checkups at the ages of 42 and 46 years. All participant annually had regular checkup and showed negligible cardiovascular defect symptoms. Figure 1 illustrates the flow of participants in the study. The study population consisted of bankers who participated in health checkup examinations from January 2006 to December 2011. Of the 3554 participants who underwent dental checkup at the age of 46 years, we analyzed data from 278 who had tooth loss 4 years prior (at the age of 42 years) that was unreplaced. Data for 60 were excluded because of a medical history that included hypertension, dyslipidemia, or hyperglycemia. Thus, findings for 218 participants were used for analysis. This study was approved by the Ethics Committee of Osaka University, Graduate School of Dentistry (H24-E18), and the requirement of written informed consent from each participant was waived by the ethics committee.

The health checkups were conducted at health support centers of

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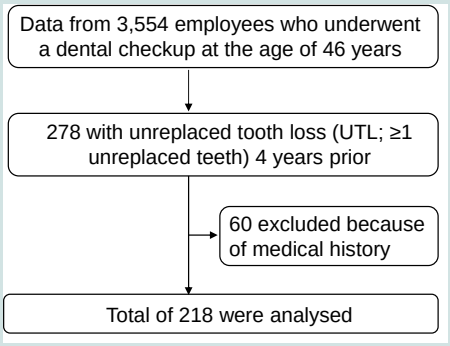

Figure 1: Flowchart of study participants.

the company branches in Osaka and Tokyo. Each medical checkup included a physical examination, collection of blood specimen for laboratory test, and a self-administered questionnaire on health behaviors. The physical examination included measurements of height and weight, and blood pressure (BP). BP was measured by trained nurses using a calibrated automatic electronic BP monitor (HM-701, Elquest Corporation, Chiba, Japan) with participants in a sitting position, after resting for at least 5 minutes. A minimum of 2 measurements were taken on an outstretched arm with a 1- to 2-minute interval in each participants. If the reading was high (systolic BP ≥130 mmHg or diastolic BP ≥85 mmHg), then additional readings were obtained, with the lowest recorded. Routine chemical methods were used to determine fasting blood glucose, high-density lipoprotein cholesterol, and triglycerides. Laboratory analysis details have been described elsewhere [16].

The self-administered questionnaire included questions about alcohol drinking habit, smoking status, and dietary pattern. The dietary section consisted of 4 questions, i.e., "How often do you eat salty foods?" to determine the intake frequency of salty, sweet, and fatty foods, and vegetables. Each answer had 3 choices; often, sometimes, and seldom.

Dental checkups were performed by 8 dentists who were appropriately trained and calibrated according to standardized procedures recommended in the manual published by the World Health Organization [17]. Dental status was recorded on an assessment form developed with reference to the manual. UTL was defined as follows: lost teeth not replaced with a denture, bridge, or implant along with functional problems, presence of prosthesis with functional problems such as fracture, lack of adaptation, and poor retention, or teeth requiring extraction for a prosthesis placement. Third molars were excluded from statistical analysis in this study.

Based on the dental checkup data, the participants were categorized into 2 groups; those who had UTL and those who did not. Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters. Participants were divided based on BMI ≥25.0 and <25.0. Alcohol drinking habit was divided into non- and current drinker, while smoking status was classified as never, former, and current. Food intake frequency was classified as often and seldom/sometimes according to answers in the questionnaire.

The characteristics of the participants were compared between groups using a chi-square test. Differences in mean values for systolic and diastolic BP, fasting blood glucose, high-density lipoprotein cholesterol, and triglycerides were evaluated using analysis of covariance, with gender, BMI, drinking habit, and smoking status as covariates. High blood pressure was defined as systolic BP ≥130 mmHg and/or diastolic BP ≥85 mmHg. A logistic regression model was constructed to calculate the odds ratio (OR) of the relationship of UTL to hypertension after adjustments for gender, BMI, drinking habit, and smoking status. Statistical analyses were employed using the PASW Statistics 18 statistical software package (IBM Corp., New York, NY, USA). The significance level was set at $P < 0.05$.

Results

Of the 218 participants who had tooth loss 4 years prior that was unreplaced, 123 (56.4%) had UTL and 95 (43.6%) did not at the age of 46 years. The mean number of UTL among those with UTL was 2.2 (standard deviation, 1.6). There were no differences in all study measures between the groups 4 years prior. Table 1 lists the characteristics of participants according to the presence of UTL. The percentage of participants with UTL was significantly higher in men than women. The distributions of drinking habit, smoking status, BMI were comparable in those with and without UTL. In addition, the difference of distribution in food frequency intake between participants with and without UTL was not significant, though the percentage of those who answered that they often eat salty foods was considerably higher in those with UTL than without (67.3% vs. 32.7%).

Figure 2 shows comparisons of adjusted means and 95% confidence intervals for BP, serum glucose, and lipids. Higher levels of both systolic and diastolic BP were observed in participants with UTL than in those without (123.4 vs. 119.4 mmHg, and 75.9 vs. 71.9 mmHg, respectively), with a statistical significance in mean

Table 1: Characteristics of participants at the age of 46 years.

Characteristics	Without UTL (n=95)	With UTL (n=123)	P-value *
Gender			
Male	81 (41.1)	116 (58.9)	0.03
Female	14 (66.7)	7 (33.3)	
Body mass index (n and %)			
<25.0	71 (46.1)	83 (53.9)	0.24
≥25.0	24 (37.5)	40 (62.5)	
Drinking habit (n and %)			
Non-drinker	21 (55.3)	17 (44.7)	0.11
Current drinker	74 (41.1)	106 (58.9)	
Smoking status (n and %)			
Never	36 (46.8)	41 (53.2)	0.78
Former	17 (42.5)	23 (57.5)	
Current	42 (41.6)	59 (58.4)	
Food intake frequency (n and %) †			
Salty foods	16 (32.7)	33 (67.3)	0.08
Sweet foods	12 (48.0)	13 (52.0)	0.64
Fatty foods	16 (41.0)	23 (59.0)	0.72
Vegetables	13 (39.4)	20 (60.6)	0.60

UTL: Unreplaced Tooth Loss

*Chi-square test.

†Number and percentage of participants who answered that they often eat that food.

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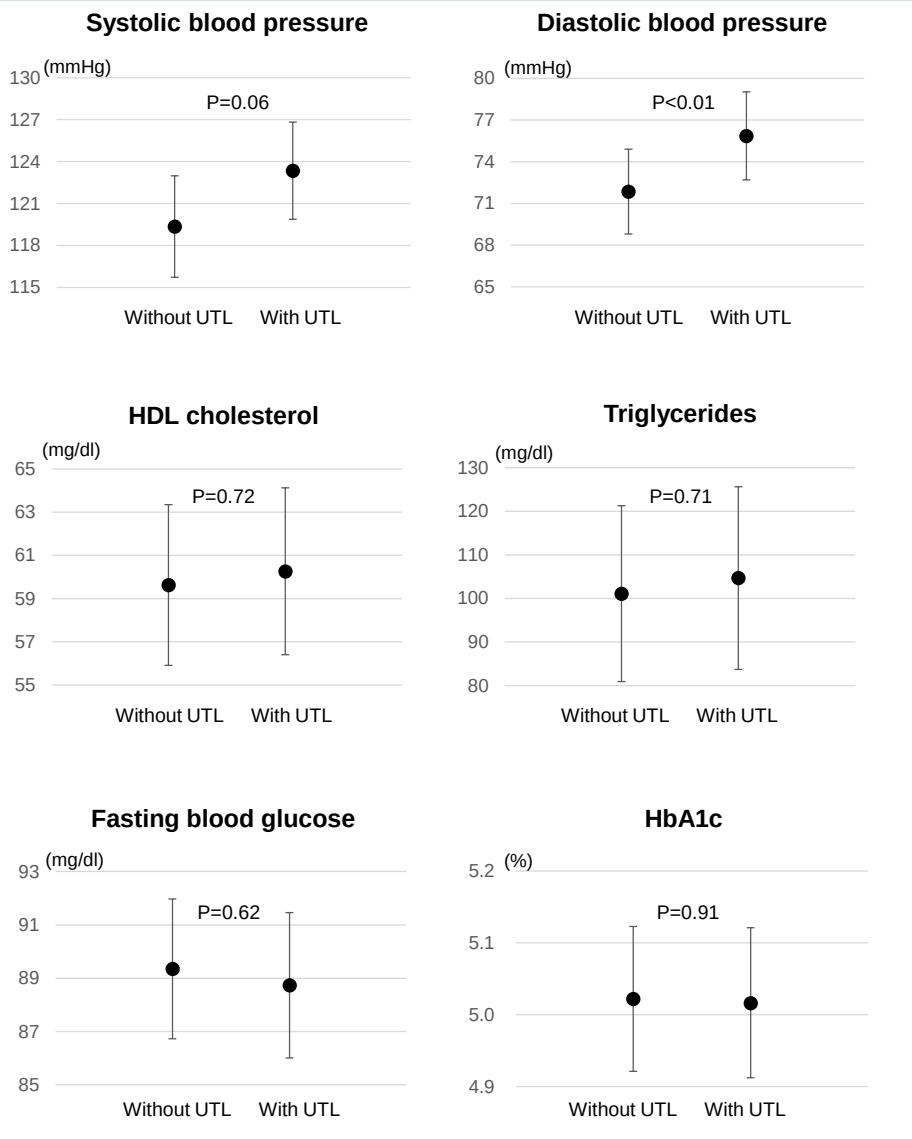

Figure 2: Comparisons of cardiometabolic markers in participants with and without UTL
UTL: Unreplaced Tooth Loss
Circles represent mean ± standard deviation.

value for diastolic BP (P<0.01), while the levels of HDL cholesterol, triglycerides, fasting blood glucose, and HbA1c were comparable between them.

Participants with UTL were more likely to have high BP (systolic BP ≥130 mmHg and/or diastolic BP ≥85 mmHg) as compared to those without UTL (37.4% vs. 17.9%). Table 2 shows crude and adjusted ORs for the various study variables in relation to high BP. Following adjustments for gender, BMI, drinking habit, and smoking status, the adjusted OR for high BP in participants with UTL was 2.61 (95% confidence interval, 1.33 to 5.09, P<0.01).

Discussion

In the present study, we evaluated the effects of UTL on cardiometabolic markers, including BP, serum glucose, and lipids, in 46-year-old employees who were found to have tooth loss 4 years prior using health checkup data. Participants with UTL had greater odds (adjusted OR = 2.6) of high BP than those without, which suggests that tooth loss left unreplaced for a certain period is related to increased BP levels in this early middle-aged population. Furthermore, it is interesting to note that a significant difference was only seen for diastolic BP. The Framingham Heart Study reported that in individuals <50 years of age, diastolic BP was a more powerful predictor of coronary heart disease risk than systolic BP [18].

The mechanisms related to BP elevation due to UTL may include chronic stress response [19], which is associated with chewing difficulties. Most forms of hypertension are associated with a wide variety of functional changes in the hypothalamus and stress stimulates the release of corticotropin-releasing factor (CRF) in that part of the brain [20], which has been shown to stimulate sympathetic activity, leading to BP elevation [21]. Chewing difficulties and imbalances

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Table 2: Odds ratio for having high blood pressure*.

Study variables	Crude OR (95%CI)	Adjusted† OR (95%CI)
Unreplaced tooth loss		
Without	1.00 (Reference)	1.00 (Reference)
With	2.74 (1.45-5.19)	2.61 (1.33-5.09)
Gender		
Male	1.00 (Reference)	1.00 (Reference)
Female	0.55 (0.18-1.71)	0.85 (0.23-3.10)
Drinking habit		
Non-drinker	1.00 (Reference)	1.00 (Reference)
Current drinker	3.14 (1.17-8.45)	2.62 (0.91-7.54)
Smoking status		
Never	1.00 (Reference)	1.00 (Reference)
Former	1.57 (0.70-3.48)	1.37 (0.57-3.30)
Current	0.73 (0.38-1.43)	0.66 (0.32-1.39)
Body mass index		
<25.0	1.00 (Reference)	1.00 (Reference)
≥25.0	2.64 (1.42-4.92)	2.50 (1.31-4.77)

OR: Odds Ratio; CI: Confidence Interval

*Systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg.

†Adjusted for gender, body mass index (<25.0, ≥25.0), drinking habit (non, current), smoking status (never, former, current).

in oral function for a certain period can cause chronic stress [22]. In rats, occlusal disharmony affected plasma corticosterone levels and noradrenaline release in the hypothalamic paraventricular nucleus [23]. Furthermore, a human study demonstrated an inverse relationship between the level of masticatory performance and sympathetic activity [24].

Several factors to be considered that possibly contribute to the relation of UTL to increased BP levels. Obesity, a well-established risk factor for high BP, has been reported to be associated with an increased risk for tooth loss [25,26]. However, the distribution of BMI (<25.0 or ≥25.0) was comparable in participants with and without UTL in this study population. Presence of periodontal disease also increases risk for tooth loss. Most cross-sectional studies have demonstrated a significant positive relationship between periodontal disease and high BP [27-29]. Our data showed no difference in periodontal status assessed by community periodontal index between participants with and without UTL, and no difference in the BP levels by periodontal status (data not shown). Assessment of periodontal condition was not mandatory as part of the dental checkup, and the missing data rate of periodontal status was approximately 30%, accordingly periodontal status was not included in our analysis. Although previous reports have shown that tooth loss causes higher intake of sweet and fatty foods, as well as lower intake of vegetables [9,10], the difference of distribution in the intake frequency of those foods between participants with and without UTL was not significant in the present study.

Participants with UTL showed a tendency for higher intake frequency of salty foods than those without UTL, though the difference was not significant. High salt intake accelerates age-related changes in vasculature [30], resulting in a rise in blood pressure. There could be several reasons for the increased intake frequency of salty foods in those participants. First, foods with a salty taste increase salivary flow [31], which can reduce chewing difficulty due to untreated tooth loss. Furthermore, salty foods may compensate for decreased pleasure in eating that accompanies chewing difficulty [32] and taste dissatisfaction [33], because salt stimulates the brain to release dopamine, a neurotransmitter that helps control the reward and pleasure centers in the brain [34]. Additional studies are needed to determine whether UTL substantially increases the intake of salty foods using a validated food frequency questionnaire [35] or objective assessment of dietary exposure [36].

Our study has several possible limitations. First, we were unable to obtain the exact dates of missing tooth replacement, because our analysis was based on data obtained in health check-up examinations. Thus, the period of time after missing teeth replacement could not be accurately determined. Second, blood pressure measurements were performed in a health check-up setting, thus hypertension was assessed based on blood pressure measurements taken at a single visit, while the Japanese Society of Hypertension recommends that diagnosis of hypertension be based on clinical blood pressure measurements conducted on at least 2 different occasions [37]. Third, socioeconomic status (SES), which is closely related to dental care utilization [38], was not considered in this study because all participants were 46-year-old bankers employed by the same company. In addition, the influence of SES on utilization, if any, may be limited, because the universal health insurance system in Japan covers an extensive range of health services including dental prosthetic treatment. Finally, the study population consisted of employees of a large banc company, thus our results cannot be generalized to other populations.

In conclusion, our results suggest that tooth loss left unreplaced for a certain period is related to increased BP levels in this early middle-aged population. Dentists are encouraged to develop treatment plans to help patients prevent and restore tooth loss for systemic health as well as dental health. Further studies are warranted to evaluate the effects of UTL on BP by employing validated assessments of dietary intake.

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