Estimating tooth retention by the number of present teeth in a middle-old-aged population: 3-year follow-up study in Korea

Prognoza zachowania zębów na podstawie liczby obecnych zębów w populacji w wieku średnim – 3-letnie badanie kohortowe w Korei

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Abstract

Background. The number of individual teeth decreases with age, resulting in a decrease in masticatory capacity, and is an important indicator of oral health. However, it is difficult to estimate the number of present teeth on the basis of age alone.

Objectives. We aimed to determine whether tooth retention could be estimated by the number of present teeth in middle-old-aged individuals.

Material and methods. We used data from the Korean Genome and Epidemiology Study on Atherosclerosis Risk of Rural Areas in the Korean General Population (KoGES-ARIRANG). Subjects (40–75 years old) were invited to participate in a 3-year prospective follow-up survey conducted from 2010 to 2014. A total of 557 individuals (219 men and 338 women) took part in the study. Tooth retention was estimated from the number of present teeth by multivariate logistic regression analysis using SPSS v. 20.0.

Results. In total, 294 (52.8%) subjects retained teeth during a 3-year follow-up period. The number of present teeth and the proportion of subjects with complete tooth retention after 3 years decreased with increasing age. A greater number of present teeth in the baseline year was associated with complete tooth retention after 3 years in a greater proportion of subjects ($p < 0.001$). Logistic regression analysis revealed that the proportion of subjects with tooth retention in the Q4 quartile (28 teeth) was 9.17 times that in the Q1 quartile (less than 26 present teeth), even after adjusting for sociodemographic factors and oral health behavior in middle-aged individuals. In elderly individuals, tooth retention in the Q4 quartile (28 teeth) was 4.50 times that in the Q1 quartile (less than 17 teeth).

Conclusions. The number of present teeth could be used to estimate tooth retention over a 3-year period. This highlights the importance of promoting oral health care in middle-aged individuals before tooth loss occurs.

Key words: oral health, tooth loss, cohort study, preventive dentistry

Słowa kluczowe: stan zdrowia jamy ustnej, utrata zębów, badanie kohortowe, stomatologia prewencyjna

Introduction

The number of teeth is an important indicator of oral health, particularly in the elderly population. The number of teeth decreases with age, resulting in a decrease in masticatory capacity.¹ Elderly individuals often choose to use a dental prosthesis, such as dentures or implants, to compensate for the loss of masticatory capacity.^{2,3} However, these prostheses do not always fully restore mastication, and patients still experience discomfort.^{4–6} Consequently, elderly patients commonly limit or exclude certain food items from their diet,⁷ which leads to malnutrition and an increased risk of systemic disease.⁸ The number of teeth is also associated with accurate pronunciation during speech.⁹ Elderly individuals with few present teeth have difficulties in pronunciation, which could lead to social exclusion. These findings indicate that tooth loss can lead to a decrease in the quality of life in elderly individuals.^{10,11} Therefore, retaining present teeth by preventing tooth loss is necessary for maintaining health during old age.

There have been many studies on the risk factors associated with tooth loss. Both sociodemographic factors, such as age, sex, marital status and cohabitation status,^{12,13} as well as socioeconomic factors, such as educational level and income level,^{14,15} have been associated with tooth loss. Poor lifestyle habits,¹⁶ including smoking and drinking, and poor oral health behavior (e.g., improper tooth brushing, lack of deep cleaning and lack of dental check-ups)¹⁷ have also been associated with tooth loss. However, recently, the paradigm has shifted from identifying risk factors of disease to investigating disease-prevention factors.^{16–19} Evidence has accumulated showing that prevention factors could help healthy people retain a healthy status.^{20,21} From the perspective of oral health, it is important to investigate the factors preventing tooth loss.

The number of present teeth is associated with age and is an important indicator of oral health;^{22,23} however, it is difficult to estimate the number of present teeth on the basis of age alone. A previous study reported that the number of present teeth in individuals at the ages of 50–59 years and 56–65 years was associated with tooth loss 6 years later.²⁴ However, in that study, it was not possible to estimate future tooth retention from the number of present teeth at baseline, because the authors used 2 separate cross-sectional or longitudinal studies to examine the effect of present teeth on tooth loss, but did not investigate the issue from the perspective of tooth retention.

Objectives

The aim of this 3-year prospective cohort study was to determine if tooth retention in elderly individuals could be estimated from the number of present teeth during middle age.

Material and methods

Study design and participants

The study protocol was approved by the Institutional Review Board of Wonju Christian Hospital in Korea (CR105024-026). All participants provided written informed consent.

We used data from the Korean Genome and Epidemiology Study on Atherosclerosis Risk of Rural Areas in the Korean General Population (KoGES-ARIRANG), which is a population-based, prospective cohort study assessing the prevalence of and risk factors for systemic and dental disease. In 2005, the KoGES-ARIRANG recruited individuals residing in rural Wonju in South Korea. Demographic shifts in the 8 districts involved are infrequent, and the population could thus be followed over a long time. The population was invited to participate in this study through the media, conferences, and telephone calls, among other methods.²⁵

The survey was performed between March 2010 and August 2014 and included 1,726 adults (711 men and 1,015 women), aged 40–75 years, who underwent an oral examination and interview. Out of these, 899 (52.1%) subjects were selected for the study. We then excluded 296 subjects with an error in the number of lost teeth, 35 (3.9%) subjects who were edentulous at baseline, and 11 (1.2%) outliers who lost more than 9 teeth for unknown reasons during the follow-up period. The final sample size for the present analysis was 557 participants (219 men and 338 women) (Fig. 1). The participants completed a standardized dental history and lifestyle questionnaire, and underwent a comprehensive oral examination including counting the number of present teeth according to standard procedures at baseline and follow-up examinations.

Fig. 1. Selection of study population

Main outcome and exposure measures

The main outcome measure was tooth retention, i.e., without the loss of 1 or more teeth, during the 3 years following the baseline year. The main exposure variable was the number of present teeth. Present teeth were operationally defined as functional teeth with crowns and roots, excluding dental implants, dentures, and pontics. The number of present teeth was counted by trained dental hygienists. Trained dental hygienists also carried out the oral examination, using a tongue depressor, with the subjects seated on a chair.

Covariates

Sociodemographic variables were based on questions used during the interview: “What is the level of your education?” (elementary school or lower, middle school, high school or higher); “What is your marital status?” (married or unmarried, including being divorced and widowed); and “Who do you live with now?” (alone, with a spouse, with children).

Oral health behavioral variables were based on the following questions: “How many times did you brush your teeth yesterday?”; “Do you use any additional oral hygiene devices, such as dental floss or an interdental brush, mouth rinse products, an electronic toothbrush, or a waterpik?”; “Have you visited a dental clinic within the last 3 years?”; and “If so, what type of treatment did you receive?” (no treatment, oral examination, dental scaling and periodontal treatment, restorative treatment, endodontic treatment, prosthetics treatment, dental implant, or not sure). In the present study, we only analyzed the responses on prevention treatment, such as dental scaling and oral examination, i.e., we did not include the data on the other treatment types. Two to 4 weeks after the survey, the surveyor randomly invited 20% of the initial participants to complete the survey again, in order to evaluate test-retest reliability; the kappa κ value was 0.967.

Statistical analysis

In this study, as there were significant differences in the sociodemographic and baseline oral health characteristics between different age groups, the population was divided into “middle” (<60 years) and “older” (≥ 60 years) age groups for analysis.

A χ^2 analysis was performed to determine differences in tooth retention distribution according to the quartiles for the number of present teeth after the baseline year. A multivariate logistic regression analysis was used to identify the factors associated with tooth retention, and the odds ratio (OR) and 95% confidence interval (CI) were calculated. A crude model and 3 models adjusted for covariates were used to investigate how the number of present teeth in the baseline year affected tooth retention. The magnitude of the effect of exposure variables on tooth retention was identified using the crude model. Similarly, model 1 was used to iden-

tify the effects of exposure variables on tooth retention after adjusting for the sociodemographic characteristics; model 2 – after adjusting for oral health behavior; and model 3 – after adjusting for sociodemographic characteristics and oral health behavior. All statistical analyses were performed using SPSS v. 20.0 for Windows (IBM Corp., Armonk, USA), and a p-value <0.05 was considered statistically significant.

Results

Participant characteristics

The mean age of the 557 participants at baseline was 57.9 ± 8.14 years (men: 59.5 years; women: 56.9 years); more women ($n = 338$, 60.7%) than men ($n = 219$, 39.3%) took part in the study. The sociodemographic characteristics of the participants are listed in Table 1.

Table 1. Sociodemographic and oral health behavior characteristics of subjects in the baseline year

Variables		n (%)
Total		557 (100.0)
Sociodemographic characteristics		
Sex	male	219 (39.3)
	female	338 (60.7)
Age [years]	40–49	95 (17.1)
	50–59	233 (41.8)
	60–69	177 (31.8)
	≥ 70	52 (9.3)
Educational level	elementary school or lower	190 (34.1)
	middle school	102 (18.3)
	high school or higher	265 (47.6)
Marital status	married	513 (92.1)
	unmarried	44 (7.9)
Cohabitation status	alone	34 (6.1)
	with a spouse	279 (50.1)
	with children	244 (43.8)
Oral health behavior		
Daily tooth brushing	at least once	59 (10.6)
	twice	304 (54.6)
	3 or more times	194 (34.8)
Using oral hygiene devices	yes	184 (33.0)
	no	373 (67.0)
Visit to a dental clinic within 3 years	yes	384 (68.9)
	no	173 (31.1)
Oral examination within the last 3 years	yes	80 (14.4)
	no	477 (85.6)
Dental scaling within the last 3 years	yes	142 (25.5)
	no	415 (74.5)

The data was analyzed with a frequency analysis.

Out of the 557 participants, 294 (52.8%) subjects did not lose any further teeth during the 3-year follow-up period. The mean number of present teeth at baseline was 24.33 ± 6.45 ; the mean number of present teeth in the following year was 22.79 ± 7.47 , and the mean number of lost teeth was 1.54 ± 2.53 .

Tooth retention according to the number of present teeth at baseline

The number of present teeth at baseline in the age group 40 to 49 was 27.4, and that in the ≥ 70 age group was 20.7. After 3 years, 68.4% of the age group 40 to 49 at baseline and 30.8% of the age group ≥ 70 , respectively, retained all of their teeth. These findings indicate that the number of present teeth and the proportion of subjects with complete tooth retention after 3 years decreased with age (Fig. 2).

The distribution of present teeth in middle-aged individuals (< 60 years) is shown in Table 2. For this analysis, we grouped the participants into quartiles ($Q_{1,2,3,4}$) according to the number of present teeth at baseline. A higher num-

Fig. 2. Present teeth in the baseline year and tooth retention 3 years later

* tooth retention after 3 years means no tooth loss during the 3 years of follow-up; ** present teeth means the mean number of present teeth in the baseline year.

Table 2. Quartiles of present teeth by patient age group and tooth retention

Quartiles of present teeth in the baseline year (the number of teeth)	n (%)	Mean $\pm$ SD [†]	Tooth retention after 3 years		
			no	yes	p-value [‡]
Middle-aged (< 60 years)	–	26.16 $\pm$ 4.18	–	–	< 0.001
total	–	–	212 (64.6)	116 (35.4)	–
Q ₁ (2–25)	63 (19.2)	–	44 (69.8)	19 (30.2)	–
Q ₂ (26–27)	72 (22.0)	–	36 (50.0)	36 (50.0)	–
Q _{3, Q₄} (28)	193 (58.8)	–	36 (18.7)	157 (81.3)	–
Older-aged (≥ 60 years)	–	21.70 $\pm$ 8.05	–	–	< 0.001
total	–	–	82 (35.8)	147 (64.2)	–
Q ₁ (1–17)	55 (24.0)	–	41 (74.5)	14 (25.5)	–
Q ₂ (18–25)	53 (23.1)	–	42 (79.2)	11 (20.8)	–
Q ₃ (26–27)	56 (24.5)	–	39 (69.6)	17 (30.4)	–
Q ₄ (28)	65 (28.4)	–	25 (38.5)	40 (61.5)	–

[†] mean $\pm$ SD – the mean number of present teeth and standard deviation; [‡] p-values are obtained from χ^2 tests.

Fig. 3. Tooth retention after 3 years according to the number of present teeth in the baseline year

[†] difference in tooth retention according to the quartile of present teeth using χ^2 tests ($p < 0.001$); [‡] one or more teeth lost (%) represents the proportion of subjects who lost 1 or more teeth during the 3-year follow-up; [§] tooth retention (%) represents the proportion of subjects who did not lose 1 or more teeth during the 3-year follow-up.

ber of present teeth at baseline was associated with better tooth retention after 3 years ($p < 0.001$). In $Q_{3,4}$ 81.3% of the subjects showed complete tooth retention, i.e., the proportion of subjects with no tooth loss was greater than that of subjects with the loss of 1 or more teeth (Table 2, Fig. 3).

The distribution of present teeth in older individuals (≥ 60 years) is also shown in Table 2. Similar to the middle-aged individuals, a higher number of present teeth at baseline was associated with better tooth retention after 3 years ($p < 0.001$). In Q_4 , 61.5% of subjects showed complete tooth retention, i.e., the proportion of subjects with no tooth loss was greater than the proportion of subjects with the loss of 1 or more teeth (Table 2, Fig. 3).

Association between tooth retention and the number of present teeth in the baseline year

In the middle-aged group, there was an association between tooth retention after 3 years and the number of present teeth at baseline in the $Q_{3,4}$ group, after ad-

Table 3. Logistic regression analysis for the association between tooth retention and present teeth during follow-up

Quartiles of natural teeth in the baseline year		Tooth retention after 3 years		
		Q ₁ (2–25)	Q ₂ (26–27)	Q _{3,4} (28)
Middle-aged (<60 years)	crude model	1	2.32* (1.14–4.71)	10.10** (5.28–19.32)
	model 1	1	2.01 ^{ns} (0.96–4.22)	9.55** (4.82–18.91)
	model 2	1	2.21* (1.07–4.55)	9.70** (5.01–18.75)
	model 3	1	1.90 ^{ns} (0.89–4.04)	9.17** (4.60–18.30)
Quartiles of natural teeth in the baseline year		Tooth retention after 3 years		
		Q ₁ (1–17)	Q ₂ (18–25)	Q ₃ (26–27) Q ₄ (28)
Older-aged (≥60 years)	crude model	1	0.77 ^{ns} (0.31–1.89)	4.69** (2.14–10.28)
	model 1	1	0.69 ^{ns} (0.27–1.75)	5.03** (2.21–11.45)
	model 2	1	0.76 ^{ns} (0.30–1.91)	3.99** (1.76–9.03)
	model 3	1	0.69 ^{ns} (0.27–1.77)	4.50** (1.93–10.52)

* $p < 0.05$; ** $p < 0.001$; ^{ns} – non-significant; crude model – unadjusted; model 1 – adjusted for quartiles of present teeth in the baseline year and sociodemographic status (age, sex, educational level, marital status, cohabitation status); model 2 – adjusted for quartiles of present teeth in the baseline year and oral health behavior (tooth brushing, using dental hygiene devices, visiting dental clinic, oral examination, and dental scaling within 3 years); model 3 – adjusted for quartiles of present teeth in the baseline year, sociodemographic status, and oral health behavior.

justing for the sociodemographic characteristics (model 1). There was also a linear association after adjusting for oral health behavior (model 2). After adjusting for both sociodemographic characteristics and oral health behavior (model 3), the proportion of subjects showing complete tooth retention after 3 years in the Q_{3,4} group (28 teeth) was retained their present teeth about 9 times more than Q₁ group (less than 26 teeth) (OR = 9.17; 95% CI, 4.60–18.30) (Table 3).

In the older age group, there was an association in the Q₄ group between tooth retention after 3 years and the number of present teeth at baseline, even after adjusting for the sociodemographic characteristics (model 1) and oral health behavior (model 2). After adjusting for the sociodemographic characteristics and oral health behaviors (model 3), the proportion of subjects showing tooth retention after 3 years in the Q₄ group (28 teeth) was retained their present teeth about 5 times more than Q₁ group (less than 26 teeth) (OR = 4.50; 95% CI, 1.93–10.52) (Table 3).

Discussion

Oral rehabilitation refers to the restoration and treatment of defective teeth.²⁶ The aim of replacing a missing tooth with a prosthesis such as an implant or a denture is to restore the esthetics and speech function of the patient. However, patients with prosthodontics have a lower ability to chew than those who have natural dentition, and hence quality of life decreases as well.⁶ In other words, it is preferable to preserve natural teeth rather than perform restorations.

Death is inevitable for all, even in the absence of disease. However, tooth loss due to aging is not inevitable; i.e., tooth loss is not a normal phenomenon in elderly individuals, although many studies have reported that tooth loss is an outcome of aging and that age is an indicator

of tooth loss.^{22,23} Age alone cannot be used to predict the number of present teeth. In this prospective cohort study, we found that the number of present teeth in middle-aged/elderly participants was associated with tooth retention at an older age, even after adjusting for sociodemographic status and oral health behavior. The number of present teeth might therefore help to estimate future tooth loss in elderly individuals.

The mean number of present teeth in the baseline year was 26.16 ± 4.18 for the middle-aged group, and 21.70 ± 8.05 for the elderly group. After adjusting for sociodemographic factors, such as age, sex, educational level, marital status, and cohabitation status, and for oral health behavior, such as tooth brushing, use of oral hygiene devices, oral examinations, and dental scaling, middle-aged subjects who had 28 present teeth at baseline retained 9.17 times more teeth than subjects who had <26 teeth. On the other hand, elderly subjects who had 28 present teeth at the baseline year retained 4.50 times more teeth than subjects who had <18 teeth in the baseline year. These findings suggest that the number of present teeth at baseline influenced tooth retention over the following 3 years.

Worthington et al. reported that fewer teeth at baseline was associated with greater tooth loss over 5 years in adults who regularly attended a dental clinic.²⁷ However, after adjusting for age, sociodemographic factors and lifestyle habits, such as smoking, no significant association was observed. In a nationwide cross-sectional study, Yoshino et al. demonstrated an association between the number of present teeth and tooth loss over a period of 6 years.²⁴ A smaller number of teeth in subjects aged 50–59 years and 56–65 years were associated with greater tooth loss after 6 years. Similarly, Eklund et al. reported that a higher percentage of subjects with fewer teeth became edentulous over a subsequent 10-year period, than did subjects with more teeth.²⁸

Our results correspond with these findings: the fewer present teeth an individual had at baseline, the greater the tooth loss that person would experience over the subsequent 3 years, even after adjusting for sociodemographic status and oral health behavior, which are known factors associated with tooth loss. Therefore, age per se was not the sole indicator of tooth loss. In fact, the number of present teeth in middle age influenced tooth retention to a greater extent than the number of present teeth at an older age. However, most oral health education programs target elderly individuals rather than middle-aged individuals. In addition, dental care is often not considered a public priority for government spending.²⁹ On the other hand, our findings suggest that preventive health policies should focus on the middle-aged or younger age groups, who have not yet experienced tooth loss.

This study has 4 notable limitations. Firstly, this study may have interview bias, as it was conducted using one-on-one interviews. The questionnaire comprised numerous questions (50), and the survey answers may have been affected by the interview environment. In addition, the participants answered the questions from memory, and recall bias may have occurred. However, the surveyors evaluated the test-retest reliability ($\kappa = 0.967$). Secondly, the study participants consisted only of middle-aged and elderly individuals living in rural Korea, so it is unclear whether the data has the representativeness of the samples. However, it has been presented that the KoGES data could be generalizable to the Korean population by comparison between the disease prevalence in the subjects from the Korean Genome and Epidemiology Study (KoGES) data and the Korea National Health and Nutrition Examination Survey (KNHANES III) data.³⁰ Also, it should be noted that useful and meaningful data which revealed a relationship between sleep duration and the incidence of hypertension used the same data as in this study.²⁵ Thirdly, this study considered only sociodemographic characteristics and oral health behavior variables, and other known risk factors for tooth loss, including systemic conditions, such as diabetes, cardiovascular disease, metabolic syndrome, and general health status and lifestyle factors, such as smoking and drinking habits, were not considered. Finally, the confidence interval was not precise, because this study was conducted using subgroups of middle-aged and elderly individuals; hence, the sample size was small.

Nevertheless, this study focused on tooth retention, rather than tooth loss, to determine the preventive factors for tooth loss, and investigated the association between the number of present teeth and tooth retention over a 3-year period, using cohort data after adjusting for sociodemographic status and oral health behavior. We found that the number of present teeth could be used to predict tooth retention after 3 years.

Conclusions

Our findings provide helpful information for developing a health policy for middle-aged individuals with no tooth loss; however, further studies are necessary to identify the factors underlying tooth longevity and to establish measures that can prevent tooth loss.

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