Tooth Loss and Decline in Functional Capacity: A Prospective Cohort Study from the Japan Gerontological Evaluation Study

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OBJECTIVES: To describe associations between tooth loss and changes in higher-level functional capacity.

DESIGN: Prospective cohort study.

SETTING: Twenty-four Japanese municipalities between 2010 and 2013.

PARTICIPANTS: Functionally independent community-dwelling persons aged 65 and older (N = 62,333).

MEASUREMENTS: Self-reported number of teeth was used as an exposure variable. The outcome was changes in higher-level functional capacity measured using the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC), which consists of three domains: instrumental activities of daily living, intellectual activity, and social roles. The TMIG-IC score ranges from 0 (lowest function) to 13 (highest function). All covariates were chosen from baseline demographic, socioeconomic, health behavior, and health variables based upon evidence from previous studies. Inverse-probability weighting (IPW) with propensity score and multiple linear regression, estimating nonstandardized coefficients (β) and 95% confidence intervals (CIs), were used.

RESULTS: The baseline response rate was 65.2%, and the follow-up rate was 70.1%. During the follow-up period, participants' TMIG-IC score declined by an average of 0.247 points (standard deviation: 1.446). The results showed a significant dose-response association between tooth loss and decline in higher-level functional capacity in multiple linear regression models. IPW models estimated the increment in TMIG-IC score (β = 0.170, 95% CI = 0.114 to 0.227) if edentulous participants gained 20 or more natural teeth.

CONCLUSION: Tooth loss is associated with future decline in higher-level functional capacity. IPW models suggest that treatment for tooth loss attenuates decline in higher-level functional capacity. **J Am Geriatr Soc 64:2336–2342, 2016.**

Key words: oral health; propensity score; independent living; tooth loss

In an aging society, physical, cognitive, and social ability are all important components of successful aging and increasing healthy life expectancy.[1] Higher-level functional capacity is a measurement not only of physical and cognitive functioning, but also of social ability, such as skills for independent community living.[2] It is composed of three domains: instrumental activities of daily living (IADLs), intellectual activity, and social roles.[2] Higher-level functional disability is an important predictor of future onset of cognitive impairment[3] and mortality.[2]

Oral diseases are an important public health problem because of their very high prevalence and significant burden in terms of disability-adjusted life years.[4] Many studies have reported the effect of oral health on general health. It has been suggested that oral health affects physical, cognitive, and social communicative abilities, which are components of higher-level functional capacity,[5–10] but the only studies examining the association between oral health or oral health behaviors and higher-level functional capacity have been cross-sectional[11,12] and did not use tooth loss as an exposure variable; only one study concluded that higher-level functional disability might lead to poorer oral health behavior.[12]

Propensity score technique is one of the best methods of determining associations between exposure and outcome in observational studies.[13,14] When examining the

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association between number of teeth and higher-level functional capacity, the ideal research design would be an intervention study to increase the number of natural teeth in edentulous people, but it is practically impossible to estimate the treatment effects of edentulous people gaining natural teeth. Therefore, inverse-probability weighting (IPW) with the propensity score was performed, and the treatment effects of tooth loss on higher-level functional capacity were evaluated.[14]

It was hypothesized that tooth loss at baseline would be predictive of future decline in higher-level functional capacity. Thus, the aim of this cohort study was to determine whether there was an association between tooth loss and decline in higher-level functional capacity.

METHODS

Data Sources and Participants

This study used repeated-measures data from the Japan Gerontological Evaluation Study (JAGES) project.[7,10,15] All participants were community-dwelling persons aged 65 and older who were physically and cognitively independent, defined as not receiving a certification of need for long-term care. The baseline survey was conducted between August 2010 and January 2012, and the follow-up survey was conducted between January 2013 and December 2013. Self-administered questionnaires were initially mailed to 24 municipalities in nine prefectures in Japan. In 10 of the municipalities, the entire population was sampled, and in the remaining 14 municipalities, the samples were randomly based on official residential registers obtained from the municipal governments. Self-administered questionnaires used for the follow-up survey were subsequently mailed to the same municipalities and participants.

Study Design

This study was a prospective cohort study.

Exposure Variable: Tooth Loss at Baseline

The self-reported number of teeth at baseline was used as the exposure variable. The questionnaire asked, "What is the status of your dental health?" with possible answers being 20 or more natural teeth, 10–19 natural teeth, 1–9 natural teeth, and no natural teeth (being edentulous).

Outcome Variable: Changes in Higher-Level Functional Capacity

Higher-level functional capacity measured using the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) was used as an outcome variable.[2] The TMIG-IC, which consists of 13 questions (responses: yes, able to do = 1; no, unable to do = 0), has been widely used in Japan and has been validated (Table S1).[2,3,16–18] The TMIG-IC score ranges from 0 (lowest function, unable to independently live in the community) to 13 (highest function, able to live independently in the community). The outcome was based on changes in higher-level functional capacity measured using the TMIG-IC, which was calculated as total follow-up TMIG-IC score minus total baseline TMIG-IC score.

Covariates

Health and health behavior variables that may be related to TMIG-IC and oral health were included in the model: sex, age (65–69, 70–74, 75–79, 80–84, ≥85), medical history (heart disease, stroke, diabetes mellitus, respiratory disease), depression (15-item Geriatric Depression Scale (GDS-15) score:[19] (0–4 = not depressed, 5–9 = depressive tendency, 10–15 = depressed),[18] number of falls over past year (none, once, more than once),[15] smoking status (never smoker, former smoker, current smoker), drinking alcohol status (current drinker, former drinker, never drinker), body mass index (BMI) (≥25.0, 18.5–24.9, <18.5 kg/m^2),[17] and baseline TMIG-IC score. In addition, because a broader range of social determinants affect behavior and oral health,[20] equalized household income (Japanese yen (JPY) ≥4.00 million, JPY 2.00–3.99 million, JPY <2.00 million; 100 JPY≈$1 at the time of the analysis; Japanese poverty line in 2009, JPY 1.25 million[21]), years of education (≥13, 10–12, 6–9, <6), marital status (married, widowed, divorced, never married),[6] living situation (alone, with spouse, with spouse and child(ren), with child(ren), other),[10] and residential area (24 municipalities) were also included in the model. Baseline TMIG-IC score was used as a continuous covariate, because it indicates health status and because it was possible that participants with high and low scores might exhibit different trends associated with changes in their TMIG-IC scores. To avoid the effect of socioenvironmental background and variation in follow-up periods in each municipality, dummy variables for the 24 municipalities were included in the models.

Statistical Analysis

Before using the regression analysis and IPW models, multiple imputation by chained equations was performed to estimate the missing values, and 10 imputed data sets were created.[22] Table S2 lists the variables used in the multiple imputation. Because the TMIG-IC has no cutoff point[2] and changes in higher-level functional capacity had a normal distribution, multiple linear regression models were used. After completion of the multiple imputation, multiple linear regression and IPW models, with estimated nonstandardized coefficients (β) and 95% confidence intervals (95% CIs), were used to analyze the association between tooth loss and changes in higher-level functional capacity as continuous outcomes. β represents changes in TMIG-IC score; a β of 0.1 indicates an increase in TMIG-IC score of 0.1 point and an improvement in higher-level functional capacity. The IPW models show quasi-experimental results of the treatment effects.[13] Therefore, IPW models were used that could estimate average treatment effect (ATE) and average treatment effect on the treated (ATET) according to multivariate independent variable.[14] ATE is the average effect of the treatment in the total population. It is the difference in TMIG-IC score when all study participants are edentulous and all gain some natural teeth. ATET is the average treatment effect in the exposed

population. It is the difference in TMIG-IC score when edentulous participants gain some natural teeth. Previous studies have shown that ATE and ATET confirm the robustness of the estimates. After calculating the propensity score, the balance in each of the imputed data sets was checked. Standardized differences and variance ratios were used to determine the success of the balancing of the IPW. Generally, standardized differences close to 0 (within ±0.1) and variance ratios close to 1 indicate the appropriateness of the balancing of IPW.[14] The propensity score was calculated using multinomial logistic regression using all of the previously listed potential confounders: sex, age, medical history (heart disease, stroke, diabetes mellitus, respiratory disease), equalized household income, years of education, marital status, living situation, depression (GDS-15), number of falls over past year, smoking status, drinking alcohol status, BMI (kg/m^2), residential area, and baseline TMIG-IC score. Analyses were performed using Stata version 14.0 (Stata Corp., College Station, TX).

Ethical Approval

The ethics committee for human participants of Nihon Fukushi University (10–05, 13–14) and the ethics committee of Tohoku University Graduate School of Medicine (24–29) reviewed and approved the JAGES project protocol.

RESULTS

Of 140,459 individuals in 24 municipalities who were mailed the questionnaire, 91,569 responded (response rate = 65.2%). Three hundred eighteen participants who reported activity of daily living disabilities in the baseline survey and 886 who reported a certification of need for long-term care in the baseline survey were excluded, leaving 90,365 eligible baseline participants. The 2013 follow-up survey was filled out by 63,341 participants (follow-up rate = 70.1%); 1,008 who did not provide matching information on self-reported sex between the baseline and follow-up surveys were excluded. After the exclusions, 62,333 participants were included in the present study. Median follow-up was 707 days (interquartile range 694–1148). Mean baseline age was 73.0 ± 5.6. Table 1 shows participants characteristics and outcomes (residential areas are shown in Table S3). During the follow-up period, participants' TMIG-IC score decreased by an average of 0.247 points (SD = 1.446). Participants with fewer than 20 teeth were older than those with 20 or more teeth. In addition, participants with fewer remaining teeth had generally lower socioeconomic status and poorer health behaviors. The number of missing values for each of the variables is shown in Table S2.

Table 2 presents the results of the multiple linear regression, which after multiple imputation, had results similar to those from before multiple imputation. The variance inflation factors of the multiple linear regression before multiple imputation were 2.71, which is a generally acceptable level. After multiple imputation and adjusting for covariates, the multiple linear regression model analysis showed that the TMIG-IC score of participants with 10–19 teeth was 0.035 points lower than the score of those with 20 or more teeth (β = −0.035, 95% CI = −0.065 to −0.005). Participants with one to nine teeth (β = −0.088, 95% CI = −0.119 to −0.056) and those who were edentulous (β = −0.178, 95% CI = −0.221 to −0.135) also had significantly lower TMIG-IC scores. Table S4 lists the balancing of IPW in each of the 10 imputed data sets. The standardized differences all being close to 0 (within ±0.1) and the variance ratios increasing to close to 1 after being weighted confirms the ability to balance the propensity score. Table 3 shows the results of the ATE and the ATET calculated from the IPW. In the ATE models, the β of the treatment effects for tooth loss is the difference in TMIG-IC score when all study participants are edentulous and all gain some natural teeth. The ATE was 0.156 (95% CI = 0.103 to 0.208) if all study participants were edentulous and all gained 20 or more natural teeth, 0.115 (95% CI = 0.064 to 0.165) if all gained 10–19 natural teeth, and 0.065 (95% CI = 0.014 to 0.115) if all gained one to nine natural teeth. In the ATET models, the β of the treatment effects for tooth loss was 0.170 (95% CI = 0.114 to 0.227) if edentulous participants gained 20 or more natural teeth, 0.130 (95% CI = 0.080 to 0.180) if they gained 10–19 natural teeth, and 0.070 (95% CI = 0.022 to 0.118) if they gained 1–9 natural teeth.

DISCUSSION

The findings of this large population-based prospective cohort study indicate that there was a dose-response association between tooth loss and decline in higher-level functional capacity over 2 years. Table 2 showed that the effect of being edentulous on higher-level functional capacity was between that of having a history of stroke and having a history of diabetes mellitus. Previous studies have reported that tooth loss is associated with physical disability and poor cognitive function.[5–7] Oral health was also associated with social communicative abilities such as speech,[8] smiling and laughing, and having conversations with family and friends.[9] The present study also indicated that tooth loss may be associated not only with physical and cognitive functions, but also with the ability to live independently in the social community.

IPW with the Propensity Score

The IPW models suggested that treatment effects for tooth loss significantly attenuated decline in higher-level functional capacity in the ATE and ATET estimation models. The ATE represented the treatment effects in all participants and the ATET represented the treatment effects in edentulous participants. The results of ATE and ATET were similar. The treatment effects of tooth loss on higher-level functional capacity were essentially the same in each assumption, indicating that the IPW models were robust.

When discussing the associations between oral health and general health, the possibility needs to be considered that there are bidirectional relationships between oral health and general health.[23] Unlike with conventional multiple regression models, IPW was used to minimize the differences in the covariates of participants to reduce potential confounding and bias and to estimate the treatment effects directly.[14,24] Therefore, the IPW analysis

Table 1. Participant Characteristics and Outcomes According to Number of Teeth (N = 62,333)

Characteristic	All Participants, N = 62,333 n (%)	≥20 Teeth, n = 22,257 %	10–19 Teeth, n = 15,953 %	1–9 Teeth, n = 15,016 %	Edentulous, n = 7,306 %
Sex					
Female	33,512 (53.8)	52.6	52.9	55.8	52.6
Male	28,821 (46.2)	47.4	47.1	44.2	47.5
Age					
65–69	20,797 (33.4)	42.8	37.7	25.2	14.3
70–74	19,051 (30.6)	32.7	31.3	30.3	23.7
75–79	13,687 (22.0)	17.2	20.6	26.4	28.7
80–84	6,650 (10.7)	6.1	8.2	13.6	22.7
≥85	2,148 (3.5)	1.2	2.1	4.5	10.6
Medical history					
Heart disease	7,024 (14.9)	13.9	14.0	15.5	17.9
Stroke	753 (1.6)	1.4	1.5	1.7	2.0
Diabetes mellitus	7,731 (16.4)	14.9	16.4	17.6	18.0
Respiratory disease	1,937 (4.1)	3.6	4.1	4.6	4.7
Equalized household income, JPY					
≥4.00 million	5,885 (11.5)	13.6	11.1	9.7	8.9
2.00–3.99 million	20,632 (40.1)	45.1	40.8	35.7	31.6
<2.00 million	24,897 (48.4)	41.3	48.1	54.6	59.5
Years of education					
≥13	10,989 (18.4)	23.1	18.2	14.6	11.9
10–12	20,960 (35.1)	39.1	36.6	32.2	26.2
6–9	26,766 (44.8)	37.1	44.0	50.8	57.2
<6	1,048 (1.8)	0.7	1.3	2.3	4.8
Marital status					
Married	44,329 (74.0)	79.9	75.1	69.7	63.6
Widowed	12,377 (20.7)	15.4	19.2	24.7	31.5
Divorced	1,958 (3.3)	2.7	3.5	3.9	3.2
Never married	1,214 (2.0)	2.1	2.2	1.8	1.7
Living situation					
Live alone	7,006 (11.7)	9.8	11.5	13.3	13.9
With spouse	23,286 (38.8)	43.6	39.6	35.3	29.9
With spouse and child(ren)	15,819 (26.4)	28.6	27.1	24.7	23.1
With child(ren)	7,887 (13.2)	9.8	12.3	15.8	19.9
Other	5,953 (9.9)	8.2	9.5	10.9	13.2
Depression (15-item Geriatric Depression Scale score)					
No depression (0–4)	38,442 (74.5)	79.7	74.6	69.5	68.9
Depressive tendency (5–9)	10,082 (19.6)	16.4	19.7	22.4	23.3
Depression (10–15)	3,048 (5.9)	4.0	5.8	8.1	7.8
Number of falls over past year					
None	42,506 (71.5)	76.4	71.8	67.5	64.7
Once	13,422 (22.6)	19.7	22.8	24.7	26.2
More than once	3,515 (5.9)	3.9	5.4	7.8	9.1
Smoking status					
Never smoker	33,873 (60.4)	63.8	59.2	58.8	54.6
Former smoker	16,139 (28.8)	28.8	29.5	27.8	30.6
Current smoker	6,036 (10.8)	7.5	11.4	13.4	14.8
Drinking alcohol status					
Current drinker	21,296 (36.4)	41.4	38.3	32.2	27.6
Former drinker	1,839 (3.2)	2.6	3.3	3.7	3.5
Never drinker	35,304 (60.4)	55.9	58.4	64.2	69.0
Body mass index, kg/m^2					
≥25.0	13,174 (22.3)	20.6	22.9	23.4	24.3
18.5–24.9	42,067 (71.3)	73.8	71.4	69.3	67.5
<18.5	3,770 (6.4)	5.6	5.7	7.3	8.2
Baseline TMIG-IC score, mean ± SD	11.7 ± 1.7	12.0 ± 1.5	11.8 ± 1.6	11.5 ± 1.9	11.2 ± 2.2
Changes in higher-level functional capacity, mean ± SD	−0.247 ± 1.446	−0.173 ± 1.277	−0.212 ± 1.401	−0.306 ± 1.549	−0.447 ± 1.784

Change in higher-level functional capacity was calculated according to total follow-up Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) score minus total baseline TMIG-IC score.

Missing values for number of teeth categories are not shown (n = 1,801).

Distribution of missing values for each of the variables is shown in Table S2.

Distribution of participants according to residential area is shown in Table S3.

Table 2. Associations Between Number of Teeth and Changes in Higher-Level Functional Capacity Determined Using Fully Adjusted Multiple Regression Models

Characteristic	β (95% Confidence Interval) *P*-Value	
	Before Multiple Imputation, n = 25,658	After Multiple Imputation, n = 62,333
Number of teeth (reference ≥20)		
10–19	−0.040 (−0.081 to 0.001) .058	−0.035 (−0.065 to −0.005) .024
1–9	−0.063 (−0.108 to −0.019) .006	−0.088 (−0.119 to −0.056) <.001
0	−0.149 (−0.211 to −0.087) <.001	−0.178 (−0.221 to −0.135) <.001
Male (reference female)	−0.091 (−0.142 to −0.041) <.001	−0.117 (−0.152 to −0.081) <.001
Age (reference 65–69)		
70–74	−0.077 (−0.118 to −0.037) <.001	−0.106 (−0.135 to −0.077) <.001
75–79	−0.189 (−0.236 to −0.141) <.001	−0.257 (−0.290 to −0.224) <.001
80–84	−0.530 (−0.595 to −0.466) <.001	−0.578 (−0.622 to −0.534) <.001
≥85	−1.212 (−1.323 to −1.101) <.001	−1.133 (−1.205 to −1.062) <.001
Medical history		
Heart disease	−0.020 (−0.067 to 0.027) .398	−0.023 (−0.061 to 0.015) .229
Stroke	−0.220 (−0.358 to −0.082) .002	−0.183 (−0.301 to −0.065) .003
Diabetes mellitus	−0.076 (−0.121 to −0.032) .001	−0.067 (−0.109 to −0.026) .002
Respiratory disease	−0.138 (−0.224 to −0.053) .001	−0.102 (−0.172 to −0.031) .005
Equalized household income, JPY (reference ≥4.00 million)		
2.00–3.99 million	−0.017 (−0.072 to 0.037) .533	−0.008 (−0.052 to 0.035) .700
<2.00 million	−0.067 (−0.123 to −0.010) .020	−0.063 (−0.109 to −0.016) <.001
Years of education (reference ≥13)		
10–12	−0.060 (−0.106 to −0.015) .010	−0.028 (−0.062 to 0.005) .100
6–9	−0.167 (−0.215 to −0.118) <.001	−0.168 (−0.205 to −0.130) <.001
<6	−0.805 (−0.963 to −0.646) <.001	−0.523 (−0.621 to −0.424) <.001
Marital status (reference married)		
Widowed	0.044 (−0.052 to 0.139) .369	0.015 (−0.045 to 0.075) .629
Divorced	0.037 (−0.093 to 0.167) .579	−0.038 (−0.125 to 0.050) .399
Never married	−0.118 (−0.264 to 0.028) .113	−0.102 (−0.205 to 0.001) .053
Living situation (reference alone)		
With spouse	−0.115 (−0.220 to −0.010) .032	−0.149 (−0.215 to −0.083) <.001
With spouse and child(ren)	−0.173 (−0.280 to −0.066) .002	−0.170 (−0.240 to −0.100) <.001
With child(ren)	−0.246 (−0.321 to −0.171) <.001	−0.239 (−0.288 to −0.189) <.001
Other	−0.155 (−0.256 to −0.055) .002	−0.161 (−0.225 to −0.097) <.001
Depression (15-item Geriatric Depression Scale score) (reference no depression (0–4))		
Depressive tendency (5–9)	−0.188 (−0.231 to −0.145) <.001	−0.240 (−0.272 to −0.207) <.001
Depression (10–15)	−0.315 (−0.389 to −0.240) <.001	−0.369 (−0.422 to −0.317) <.001
Number of falls over past year (reference None)		
Once	0.018 (−0.022 to 0.059) .370	−0.002 (−0.031 to 0.026) .880
More than once	−0.093 (−0.167 to −0.018) .015	−0.118 (−0.171 to −0.064) <.001
Smoking status (reference never smoker)		
Former smoker	−0.045 (−0.094 to 0.003) .067	−0.027 (−0.064 to 0.011) .17
Current smoker	−0.112 (−0.177 to −0.048) .001	−0.134 (−0.180 to −0.088) <.001
Drinking alcohol status (reference Current drinker)		
Former drinker	−0.069 (−0.160 to 0.021) .134	−0.098 (−0.170 to −0.026) .008
Never drinker	−0.055 (−0.094 to −0.015) .007	−0.062 (−0.090 to −0.034) <.001
Body mass index, kg/m^2 (reference ≥25.0)		
18.5–24.9	0.022 (−0.017 to 0.061) .262	0.034 (0.004 to 0.063) .02
<18.5	−0.145 (−0.225 to −0.066) <.001	−0.084 (−0.137 to −0.031) .002
Baseline TMIG-IC score	−0.241 (−0.251 to −0.230) <.001	−0.264 (−0.271 to −0.256) <.001

Residential areas were included in each model, but the results are not shown in the table.
TMIG-IC = Tokyo Metropolitan Institute of Gerontology Index of Competence

could show more clearly the association between tooth loss and changes in higher-level functional capacity and the treatment effects for tooth loss. IPW indicated a significant treatment effect of tooth loss on higher-level functional capacity was found in. Therefore the present study has provided robust evidence of the association between tooth loss and higher-level functional capacity and has demonstrated that treatment to replace missing natural teeth could attenuate decline in higher-level functional capacity.

Mechanism

There are several possible pathways that could be responsible for the association between tooth loss and decline in higher-level functional capacity. First, an inflammation pathway is possible. Tooth loss reflects history of periodontal disease and accumulation of caries.[25] Oral inflammation has been shown to be associated with biological markers of inflammation such as high C-reactive protein and fibrinogen.[26] Chronic inflammation has also been

Table 3. Treatment Effects of Tooth Loss on Changes in Higher-Level Functional Capacity Determined Using Inverse-Probability Weighting Models

Number of Teeth (reference 0)	β (95% Confidence Interval) *P*-Value	
	Average Treatment Effect, n = 62,333[a]	Average Treatment Effect on the Treated, n = 62,333[b]
≥20	0.156 (0.103 to 0.208) .012	0.170 (0.114 to 0.227) .004
10–19	0.115 (0.064 to 0.165) <.001	0.130 (0.080 to 0.180) <.001
1–9	0.065 (0.014 to 0.115) <.001	0.070 (0.022 to 0.118) <.001

The propensity score was calculated using multinomial logistic regression using all previously listed potential confounders: sex, age, medical history (heart disease, stroke, diabetes mellitus, respiratory disease), equalized household income, years of education, marital status, living situation, depression (15-item Geriatric Depression Scale score), number of falls over past year, smoking status, drinking alcohol status, body mass index (kg/m^2), residential area, baseline Tokyo Metropolitan Institute of Gerontology Index of Competence score.

[a]Treatment effects of tooth loss when all study participants are edentulous and all gain ≥20 teeth, 10–19 teeth, or 1–9 teeth.

[b]Treatment effects of tooth loss if edentulous participants gained ≥20 teeth, 10–19 teeth, or 1–9 teeth.

found to be associated with physical and cognitive disability.[27] It is also known that poor oral health habits increase oral inflammation.[26] Second, psychosocial aspects of oral health might also affect higher-level functional capacity, because TMIG-IC includes social communicative ability such as visiting friends and talking to people. The human face is an important tool for social communication,[28] and oral health affects facial esthetics and social communicative ability.[8,9] Third, there might be a nutritional pathway that explains the link between tooth loss and higher-level functional capacity. Severe tooth loss is a risk factor for poor nutritional status, because the number of natural teeth plays an important role in chewing ability.[29] People with poor nutritional status tend to have physical and cognitive decline but also decline in higher-level functional capacity.[16]

Limitations

This study had some limitations. The first limitation involved the self-report of number of teeth and TMIG-IC in the questionnaire. This opens the possibility of self-reporting bias, but previous studies performed in the JAGES project have documented the validity of self-reported questionnaires.[30] Second, the follow-up period was fairly short (median 707 days), although the findings showed a significant decline in higher-level functional capacity, especially in older participants. There was a dose-response association between tooth loss and decline in the higher-level functional capacity, suggesting that the results are robust. Third, variability was observed in the follow-up period for each municipality. To exclude the effect of the diverse follow-up period, a fixed-effect term was included for municipalities so that follow-up period could not affect the association between tooth loss and decline in higher-level functional capacity. Fourth, 27,024 participants were lost to follow-up. The lost participants were older and had poorer higher-level functional capacity scores and poorer oral health than those who were successfully followed. These differences could have biased the association.

Implications

The results of this study indicate the importance of maintaining teeth in later life to maintain functional capacity. It is therefore essential that adults and older people be given appropriate support to maintain good oral health self-care practices and that clinical dental teams provide high-quality evidence-based care to ensure that teeth are retained into older age.

Generalizability

Although the present study was conducted in Japan, previous studies have investigated similar associations between oral health and general health in other populations. Therefore, this current study results might be acceptable internationally.

CONCLUSION

The findings of this prospective cohort study highlight that tooth loss is associated with future decline in higher-level functional capacity in a large cohort of older people.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Thirteen questions of the Tokyo Metropolitan Institute of Gerontology Index of Competence

Table S2. Numbers and percentage of missing variables for the characteristics (n = 62,333)

Table S3. Residential areas of the participants examined for the number of remaining teeth categories (n = 62,333)

Table S4. IPW balancing check for each imputed data set

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