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Impact of oral self-care on incident functional disability in elderly Japanese: the Ohsaki Cohort 2006 study

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ABSTRACT

Objectives To assess whether oral self-care (tooth brushing, regular dental visits and use of dentures) affects incident functional disability in elderly individuals with tooth loss.

Design A 5.7-year prospective cohort study.

Setting Ohsaki City, Japan.

Participants 12 370 community-dwelling individuals aged 65 years and older.

Primary outcome measures Incident functional disability (new long-term care insurance certification).

Results The 5.7-year incidence rate of disability was 18.8%. In comparison with participants who had ≥20 teeth, the HRs (95% CIs) for incident functional disability among participants who had 10–19 and 0–9 teeth were 1.15 (1.01–1.30) and 1.20 (1.07–1.34), respectively (p trend<0.05). However, the corresponding values for those who brushed their teeth ≥2 times per day were not significantly higher in the '10–19 teeth' and '0–9 teeth' groups (HRs (95% CI) 1.05 (0.91–1.21) for participants with 10–19 teeth, and 1.09 (0.96–1.23) for participants with 0–9 teeth), although HRs for those who brushed their teeth <2 times per day were significantly higher (HRs (95% CI) 1.32 (1.12–1.55) for participants with 10–19 teeth, and 1.33 (1.17–1.51) for participants with 0–9 teeth). Such a negating association was not observed for other forms of oral self-care.

Conclusions Tooth brushing may partially negate the increased risk of incident functional disability associated with having fewer remaining teeth.

Strengths and limitations of this study

► Our study is the first reported study to have demonstrated an impact of tooth brushing on the increased risk of incident functional disability resulting from having fewer remaining teeth.

► This is a large population-based cohort study involving 12 370 individuals and it can take into account considerable confounding factors.

► Although misclassification of the number of teeth and practicing oral self-care as a result of self-reporting might have occurred, the validity of these have also been confirmed by previous studies.

INTRODUCTION

As society ages, disability prevention has become an important public health issue. It has been pointed out by the WHO that oral health is an important component of healthy ageing, particularly in the disadvantaged elderly.[1] Tooth loss is also known to be a risk factor for mortality in the elderly.[2 3] Periodontal disease, which is one of the main causes of tooth loss, is known to be related to coronary heart disease,[4] stroke[4] and pneumonia,[5] which in turn are major causes of incident disability.[6] Recently, several studies have indicated that tooth loss is related to incident disability.[7 8] Therefore, there is a need to decrease the excess risk of functional disability in elderly adults with missing teeth.

It has been suggested that oral self-care has a preventative impact on mortality.[9] We have reported that individuals who practiced three types of oral self-care (tooth brushing, regular dental visits and use of dentures) had a lower mortality risk than those who practiced none of the three.[9] Those who practiced oral self-care also had a lower risk of dementia and cardiovascular disease.[10 11] These findings suggest that there are possible pathways linking oral self-care to incident disability. Additionally, it has been reported that the intra-oral environment affects the gut microbiota and may cause systemic inflammation,[12] implying a new pathway whereby poor oral hygiene may be linked to systemic disease. To our knowledge, however, only two studies have examined whether practicing oral care affects the risk of functional disability among older people with tooth loss, and those studies focused only on denture use[13] or regular dental visits.[14]

The aim of the present cohort study was to assess whether three types of oral self-care (tooth brushing, regular dental visits and use of dentures) have an impact on

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incident functional disability in individuals with tooth loss.

MATERIALS AND METHODS
Study design, setting and participants
This study was based on data from the Ohsaki Cohort 2006 Study, whose design has been described in detail elsewhere.[15] Briefly, the source population for the baseline survey comprised all men and women aged 65 years or older living in Ohsaki City, Miyagi Prefecture, northeastern Japan, on 1 December 2006. The survey included questions about the number of remaining teeth and oral self-care status, as well as items on history of disease, education level, smoking, alcohol drinking, body weight, height, psychological distress score, time spent walking per day and food intake frequency.

The baseline survey was conducted between 1 December and 15 December 2006, and the follow-up survey between 1 April 2007 and 30 November 2012. A questionnaire was distributed by the heads of individual administrative districts to all individuals aged 65 years or older living in Ohsaki city, and then collected by mail. Among 31 694 subjects (12 750 men and 18 944 women) eligible for this analysis, 23 091 (9605 men and 13 486 women) provided valid responses and formed the study cohort. Among the latter respondents, we excluded 6333 individuals who did not provide written consent for review of their long-term care insurance (LTCI) information, 2102 who had already been certified as having a disability by the LTCI before the starting date of follow-up (30 March 2007), 62 who had died or moved away before the starting date of follow-up, 188 for whom the Doctor's Opinion Paper had been unavailable and 2036 who left blank the item concerning dental health status. Thus, 12 370 responses were analysed for the purpose of this study.

During the 5.7-year period covered by the study, only 158 individuals were lost to follow-up because they moved away from the study area without developing any functional disability; thus, the follow-up rate was 98.7%. From 61 581 person-years, incident functional disability was recorded in 2329 persons, and the number of all-cause deaths was 1446.

Measurement of dental health status
In the baseline questionnaire, we asked respondents to classify the number of their remaining teeth into six categories: all (28 teeth), most (25–27 teeth), moderate (20–24 teeth), about half (10–19 teeth), few (1–9 teeth) and none (0 teeth). Then, we divided the respondents into three groups: (1) ≥20 teeth, (2) 10–19 teeth and (3) 0–9 teeth.

We also asked whether they used dentures and whether they visited a dental clinic (including as reasons 'treatment' and 'other reasons such as dental check-ups and scaling') at least once a year. The respondents were asked to mark 'yes' or 'no' in reply. We also asked how many times participants brushed their teeth daily.

Measurements of other variables
K6 was used as an indicator of psychological distress.[16 17] Using six questions, respondents were asked about their mental status over the last month. Total point scores ranged from 0 to 24. As the optimal cut-off point for mental illness in the validation study, we classified individuals with scores of ≥13 as having psychological distress.[18]

The amount of energy intake (except that from alcohol drinking) and protein intake was calculated based on the data from the baseline survey and divided into sex-specific tertiles. The survey included questions about the frequency of recent average consumption of 39 daily food items. For estimation of energy and protein intake from the food-frequency questionnaire (FFQ), a food composition table was used that corresponded to the items listed in the questionnaire.[19] A validation study of the FFQ had been conducted previously.[19]

LTCI system in Japan
In this study, we defined incident functional disability as certification for LTCI in Japan, which uses a nationally uniform standard of functional disability. LTCI is a mandatory system of social insurance to assist the daily activity of frail elderly individuals.[20 21] Everyone aged 40 years and over pays premiums, and everyone aged 65 years and over is eligible for formal caregiving services. When a person applies to the municipal government for benefits, an expert investigator visits his or her home and assesses the degree of functional disability using a questionnaire developed by the Ministry of Health, Labour and Welfare. Then, the municipal government calculates the standardised scores for physical and mental functions on the basis of the certification survey sheet and assesses whether the applicant is eligible for LTCI benefits. If a person is judged to be thus eligible, the Municipal Certification Committee decides on one of seven levels of support, ranging from support level 1 to 2, and care level 1 to care level 5. Briefly, LTCI certification levels are defined as follows. Support level 1: 'limited in instrumental activities of daily living but independent in basic activities of daily living'; care level 2: 'requiring assistance in at least one basic ADL task'; care level 5: 'requiring care in all ADL tasks'. A community-based study has shown that levels of LTCI certification are well related to the ability to perform activities of daily living, and with Mini-Mental State Examination scores.[22] LTCI certification has already been used as a measure of incident functional disability in the elderly.[7 23]

Follow-up and case details
Incident functional disability was defined as LTCI certification, which was set as our endpoint. The primary outcome was new LTCI certification (support level 1 or higher), and deaths without LTCI certification were treated as censored. We obtained a data set that included information on the date of LTCI certification, emigration or death from Ohsaki City Government based on an agreement about the secondary use of data. LTCI

certification information was provided, including care level information. All data were transferred from the Ohsaki City Government yearly each December under the agreement related to Epidemiologic Research and Privacy Protection.

Ethical issues

The return of completed questionnaires was considered to imply consent to participate in the study involving the baseline survey data and subsequent follow-up of death and emigration. Information regarding LTCI certification status was confirmed after obtaining written consent returned from the participants at the time of the baseline survey. The Ethics Committee of Tohoku University Graduate School of Medicine reviewed and approved the study protocol.

Statistical analysis

Baseline characteristics were evaluated using the χ^2 test for categorical variables and analysis of variance for continuous variables. We used these methods to compare variables among groups with varying numbers of teeth.

First, we examined the relationship between the number of remaining teeth and incident functional disability in the entire study population. The Cox proportional hazards model was used to calculate the HRs and 95% CIs for incident functional disability according to the categories for different numbers of remaining teeth. Participants having ≥20 teeth were used as a reference category. The multivariate models were adjusted for the following variables: age (65–69, 70–74, 75–79, 80–84 and ≥85 years), sex, education level (age on final graduation from school <16, 16–18, ≥19 years, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5–24.9, ≥25.0, missing), time spent walking daily (<30 min per day, 30 min per day–1 hour per day, >1 hour per day, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing) and protein intake (sex-specific tertile, missing).

Second, in this analysis, we examined whether a higher risk of incident disability among participants with fewer

Table 1 Relationship between number of teeth and participant characteristic (n=12 370)

Characteristic	Number of teeth		
	≥20, n=4047	10–19, n=3108	0–9, n=5215
Women, %	50.0	53.4	58.2
Age, mean±SD	71.3±4.8	72.8±5.2	75.6±6.2
Body mass index, kg/m², %			
<18.5	3.2	4.9	6.2
18.5–24.9	63.8	64.0	65.3
≥25.0	32.9	31.1	28.5
Current smoking, %	11.0	14.5	14.6
Current alcohol drinking, %	46.1	41.3	31.7
Education<16 years, %	22.9	27.2	33.7
Daily walking time≥1 hour, %	29.3	29.1	26.0
Medical history, %			
Stroke	2.2	2.9	3.1
Hypertension	43.5	43.5	43.5
Myocardial infarction	3.8	4.4	5.9
Diabetes mellitus	10.5	11.5	12.6
Psychological distress, %*	3.4	4.2	5.6
Energy intake, kcal/day, mean±SD†	1463.5±406.9	1451.9±401.7	1413.8±393.7
Protein intake, g/day, mean±SD	54.7±14.0	53.6±14.3	52.5±14.4
Use of dentures, %	27.3	75.1	93.0
Tooth brushing (times/day)	2.0±0.9	1.9±1.1	1.8±0.9
≥1 dental visits per year, %			
For treatment	57.3	63.5	43.8
For other reasons	39.5	34.3	19.7

*Kessler six-item psychological distress scale score ≥13.
†Excluding alcohol.

teeth would persist irrespective of whether they practice oral self-care ('tooth brushing ≥2 times per day', 'visiting a dentist ≥1 times per year' and 'use of dentures' being defined as 'practicing oral self-care'). For this, participants were divided into the following five categories based on three oral self-care measures: (1) 'having ≥20 teeth', (2) 'practicing oral self-care and having 10–19 teeth', (3) 'non-practicing and having 10–19 teeth', (4) 'practicing and having 0–9 teeth' and (5) 'non-practicing and having 0–9 teeth'. Cox proportional hazards models were used to calculate the HRs and 95% CIs for incident functional disability to compare the four categories of missing teeth with the ≥20 teeth category.

All statistical analyses were performed with SAS V.9.4 (SAS), and all statistical tests were two sided. Differences at p<0.05 were considered to be statistically significant.

RESULTS
Baseline characteristics
In the study population, women accounted for 54.3% and the mean (SD) age was 73.5 (5.4) years. Table 1 shows the participant characteristics. Those who had more teeth were younger, and were less likely to be women, current smokers and to have a history of stroke, myocardial infarction or diabetes mellitus. Having more teeth was also related to being better educated, spending more time walking, being a current drinker, and having higher energy and protein intake.

Number of teeth and incident functional disability
The number of remaining teeth was significantly associated with a higher risk of incident functional disability. The multiple adjusted HRs (95% CIs) for incident functional disability among participants having 10–19 and 0–9 teeth were 1.15 (1.01–1.30) and 1.20 (1.07–1.34), respectively, compared with participants having ≥20 teeth (p trend <0.05) (see online supplementary table S1).

Oral self-care and incident functional disability
Table 2 shows the relationship between oral self-care (tooth brushing, dental visits and use of dentures) and incident functional disability in the five categories. Compared with participants who had 20 or more teeth, HRs for participants who brushed their teeth <2 times per day were significantly higher (multivariate HRs (95% CI) 1.32 (1.12–1.55) for participants with 10–19 teeth, and 1.33 (1.17–1.51) for participants with 0–9 teeth), but HRs for participants who brushed their teeth ≥2 times per day were not significantly higher in the '10–19 teeth'

Table 2 Relationship between oral self-care and incident functional disability stratified according to number of teeth (n=12370)

Oral self-care and number of teeth	Participants, n	Person-years	Events, n (%)	HR (95% CI) Model 1*	HR (95% CI) Model 2†
Tooth brushing					
≥20	4047	21152	476 (11.8)	1.00 (reference)	1.00 (reference)
10–19 with brushing teeth≥2 per day	1977	10200	300 (15.2)	1.05 (0.91 to 1.22)	1.05 (0.91 to 1.21)
10–19 with brushing teeth<2 per day	1131	5529	230 (20.3)	1.44 (1.23 to 1.69)	1.32 (1.12 to 1.55)
0–9 with brushing teeth≥2 per day	2840	13888	634 (22.3)	1.15 (1.01 to 1.30)	1.09 (0.96 to 1.23)
0–9 with brushing teeth<2 per day	2375	10812	689 (29.0)	1.52 (1.35 to 1.72)	1.33 (1.17 to 1.51)
≥1 dental visits per year					
≥20	4047	21152	476 (11.8)	1.00 (reference)	1.00 (reference)
10–19 with dental visits	2010	10208	335 (16.7)	1.17 (1.02 to 1.35)	1.14 (0.99 to 1.32)
10–19 with no dental visits	1098	5521	195 (17.8)	1.23 (1.04 to 1.46)	1.16 (0.98 to 1.38)
0–9 with dental visits	2343	11502	528 (22.5)	1.26 (1.11 to 1.42)	1.15 (1.01 to 1.31)
0–9 with no dental visits	2872	13198	795 (27.7)	1.36 (1.21 to 1.54)	1.23 (1.09 to 1.39)
Use of dentures					
≥20	4047	21152	476 (11.8)	1.00 (reference)	1.00 (reference)
10–19 with use of dentures	2333	11770	411 (17.6)	1.18 (1.04 to 1.35)	1.15 (1.01 to 1.32)
10–19 with no use of dentures	775	3958	119 (15.4)	1.22 (1.00 to 1.49)	1.13 (0.92 to 1.38)
0–9 with use of dentures	4850	23087	1220 (25.2)	1.29 (1.15 to 1.44)	1.19 (1.06 to 1.33)
0–9 with no use of dentures	365	1613	103 (28.2)	1.66 (1.34 to 2.06)	1.35 (1.09 to 1.68)

*Model 1: adjusted for age (65–69, 70–74, 75–79, 80–84 and ≥85 years) and sex.
†Model 2: adjusted for model 1+education level (age on final graduation from school <16, 16–18, ≥19 years, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5–24.9, ≥25.0, missing), time spent walking daily (<30min/day, 30min/day–1 hour/day, >1 hour/day, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing) and protein intake (sex-specific tertile, missing).

Table 3 Sensitivity analysis of the relationship between oral self-care and incident functional disability according to number of teeth (n=8323)

Oral self-care and number of teeth	Participants, n	Person-years	Events, n (%)	HR (95% CI) Model 1*	Model 2†
10–19 teeth (n=3108)					
Brushing teeth<2 per day	1131	5529	230 (20.3)	1.00 (reference)	1.00 (reference)
Brushing teeth≥2 per day	1977	10200	300 (15.2)	0.73 (0.61 to 0.87)	0.80 (0.66 to 0.96)
No dental visits	1098	5521	195 (17.8)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2010	10208	335 (16.7)	0.95 (0.79 to 1.13)	0.98 (0.82 to 1.17)
No use of dentures	775	3958	119 (15.4)	1.00 (reference)	1.00 (reference)
Use of dentures	2333	11770	411 (17.6)	0.97 (0.79 to 1.19)	1.00 (0.81 to 1.23)
0–9 teeth (n=5215)					
Brushing teeth<2 per day	2375	10812	689 (29.0)	1.00 (reference)	1.00 (reference)
Brushing teeth≥2 per day	2840	13888	634 (22.3)	0.75 (0.67 to 0.84)	0.81 (0.73 to 0.91)
No dental visits	2872	13198	795 (27.7)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2343	11502	528 (22.5)	0.92 (0.82 to 1.03)	0.94 (0.84 to 1.05)
No use of dentures	365	1613	103 (28.2)	1.00 (reference)	1.00 (reference)
Use of dentures	4850	23087	1220 (25.2)	0.78 (0.64 to 0.96)	0.88 (0.71 to 1.07)

*Model 1: adjusted for age (65–69, 70–74, 75–79, 80–84 and ≥85 years) and sex.
†Model 2: adjusted for model 1+education level (age on final graduation from school <16, 16–18, ≥19 years, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²;<18.5, 18.5–24.9, ≥25.0, missing), time spent walking daily (<30 min/day, 30 min/day–1 hour/day, >1 hour/day, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing) and protein intake (sex-specific tertile, missing).

and '0–9 teeth' groups (multivariate HRs (95% CI) 1.05 (0.91–1.21) for participants with 10–19 teeth, and 1.09 (0.96–1.23) for participants with 0–9 teeth). There was no significant difference in the increased risk between these two subgroups, irrespective of whether or not participants undertook dental visits or used dentures. We analysed '0–9 teeth for other reasons (such as dental check-ups and scaling)' as an exposure (see online supplementary table S2). Compared with participants who had 20 or more teeth, only the HR for participants who had 10–19 teeth and visited a dentist was not significant. No such relationship was observed for 'dental visits for treatment' as an exposure.

Additionally, we compared HRs for participants who did and did not practice oral self-care in each of the '10–19 teeth' and '0–9 teeth' subgroups (table 3). Compared with participants who brushed their teeth <2 times per day, HRs for participants who brushed their teeth ≥2 times per day were significantly lower (multivariate HRs (95% CI) 0.80 (0.66–0.96) for participants with 10–19 teeth (p value<0.001), and 0.81 (0.73–0.91) for participants with 0–9 teeth (p value<0.05)). However, there was no significant difference in either of these subgroups, irrespective of whether or not participants undertook dental visits or used dentures. When we conducted reanalysis after excluding the participants with '0 teeth', the results did not change substantially: 0.80 (0.69–0.94) for participants with 1–9 teeth.

DISCUSSION

This cohort study investigated the association between oral self-care and incident functional disability. First, we found that tooth loss was significantly associated with an increased risk of incident functional disability, in agreement with previous studies.[7] [8] However, even among participants who had fewer remaining teeth, the risk for those who brushed their teeth frequently was not significantly higher. Among participants who had 10–19 teeth, we also observed a similar result for those who made dental visits for other reasons (such as dental check-ups and scaling). Our study suggested that if individuals with fewer than 20 teeth practiced good oral self-care habits such as regular tooth brushing and preventive dental visits, they might partially negate the expected increase in incident functional disability. This study had a number of strengths: (1) it was a large population-based cohort study involving 12 370 individuals, (2) it had a follow-up rate of almost 100%, (3) it took into account considerable confounding factors and (4) it is the first reported study to have demonstrated an impact of tooth brushing on the increased risk of incident functional disability resulting from having fewer remaining teeth.

There are several possible pathways linking oral self-care to incident functional disability. First, periodontal disease is related to systemic inflammation through oral inflammation.[24] Second, a recent report has suggested that swallowing of oral bacteria affects the gut microbiota, causing

5

systemic inflammation.[12] Chronic inflammation is known to be a risk factor for atherosclerotic diseases including stroke[25] and dementia,[26] and may cause autoimmune disease, particularly rheumatoid arthritis.[27] These diseases and their symptoms are common causes of functional disability in the Japanese elderly population.[28] Indeed, a previous study has suggested that tooth brushing ameliorates the risk of cardiovascular disease.[11] Therefore, better oral hygiene through tooth brushing may reduce the risk of functional disability in the elderly.

This study had several limitations. First, misclassification of the number of teeth and practicing oral self-care as a result of self-reporting might have occurred. However, the validity of the self-reported number of teeth has been confirmed by previous studies,[29] and similarly the validity of self-reported dental visits has also been confirmed.[30] Second, among the source population of 31 694, the rate of valid responses (72.9%, n=23 091) for this study was not high. In addition, the valid responses would have shown a bias towards healthier people living in the community. However, this bias would not have affected the internal validity of the association between oral self-care and incident functional disability. Third, we did not consider causes of incident functional disability. Thus, the mechanisms responsible for the reduction of incident functional disability risk resulting from oral self-care remained unidentified. Fourth, although we observed the preventive association even after adjusting for major characteristics/behaviour, not all potential confounding factors were considered. For example, although cognitive function and income might be possible confounders, we did not include them as adjustment items.

In conclusion, this study has shown that tooth brushing may partially negate the increased risk of incident functional disability resulting from having fewer remaining teeth. Further studies will need to confirm the effects of oral self-care on incident functional disability in individuals with missing teeth.

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