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Research Article

Oral Frailty as a Risk Factor for Physical Frailty and Mortality in Community-Dwelling Elderly

Tomoki Tanaka, MHM,[1,2] Kyo Takahashi, PT, PhD,[1] Hirohiko Hirano, DDS, PhD,[3] Takeshi Kikutani, DDS, PhD,[4] Yutaka Watanabe, DDS, PhD,[3] Yuki Ohara, DH, PhD,[5] Hiroyasu Furuya, DDS, PhD,[4] Tsuji Tetsuo,[1] Masahiro Akishita, MD, PhD,[2] and Katsuya Iijima, MD, PhD[1,*]

[1]Institute of Gerontology, University of Tokyo, Tokyo [2]Department of Geriatric Medicine, University of Tokyo, Tokyo [3]Tokyo Metropolitan Institute of Gerontology, Tokyo [4]Division of Clinical Oral Rehabilitation, Nippon Dental University Graduate School of Life Dentistry at Tokyo, Tokyo [5]Department of Oral Health Care Education, Tokyo Medical and Dental University, Tokyo, Japan

*Address correspondence to: Katsuya Iijima, MD, PhD, 8th Building 613, Department of Engineering, Hongo 7-3-1, Bunkyo-ku, Tokyo, Japan. E-mail: iijima@iog.u-tokyo.ac.jp

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Abstract

Background: Oral health is important for maintaining general health among the elderly. However, a longitudinal association between poor oral health and general health has not been reported. We investigated whether poor oral status can predict physical weakening (physical frailty, sarcopenia, and subsequent disability) and identified the longitudinal impact of the accumulated poor oral health (i.e. oral frailty) on adverse health outcomes, including mortality.

Methods: A total of 2,011 elderly individuals (aged ≥ 65 years) participated in the baseline survey of the Kashiwa study in 2012. At baseline, 16 oral status measures and covariates such as demographic characteristics were assessed. As outcomes, physical frailty and sarcopenia were assessed at baseline and at follow-up in 2013 and 2014. Physical independence and survival were assessed from 2012 to 2016 at the time of long-term care certification and time of death.

Results: Poor oral status as determined by the number of natural teeth, chewing ability, articulatory oral motor skill, tongue pressure, and subjective difficulties in eating and swallowing significantly predicted future physical weakening (new onsets of physical frailty, sarcopenia, and disability). Oral frailty was defined as co-existing poor status in ≥3 of the six measures. Sixteen per cent of participants had oral frailty at baseline, which was significantly associated with 2.4-, 2.2-, 2.3-, and 2.2-fold increased risk of physical frailty, sarcopenia, disability, and mortality, respectively.

Conclusion: Accumulated poor oral status strongly predicted the onset of adverse health outcomes, including mortality among the community-dwelling elderly. Prevention of oral frailty at an earlier stage is essential for healthy aging.

Keywords: Death, Disability, Oral health, Frail elderly

As the elderly population grows worldwide, prolongation of healthy life expectancy is gaining importance. The Japanese public long-term care prevention project was started in 2006 (1). Frailty is a biological syndrome associated with a decline in physical status and activities, and increased vulnerability to adverse health outcomes (2). Sarcopenia is a key component of physical frailty (3). Particularly, sarcopenia is a distinctly reportable disease according to the international medical community because the International Classification of Diseases (ICD) included a new code for sarcopenia (ICD-10-CM code M62.84). This suggests the importance of evaluating both physical frailty and sarcopenia as different outcomes.

A previous report suggested that early intervention in the frail elderly would reduce the costs of care (4). Thus, frailty and sarcopenia are considered important factors in geriatric studies and prevention of long-term care (5). It is therefore important to develop an effective early prevention method with a view to delaying new onsets

of physical frailty and sarcopenia, reducing the subsequent need for long-term care insurance and mortality.

Poor oral health among the elderly is an important issue in general health, due to associations with the pathogenesis of frailty, which suggests a multidimensional geriatric syndrome (6,7), and only a few of longitudinal associations (8–11). Furthermore, the World Health Organization has advocated effective health promotion and intervention methods for improving oral health (12). However, few large-scale studies have examined longitudinal associations between comprehensively evaluated oral status and physical weakening such as physical frailty, sarcopenia, and long-term care needs in the elderly (6, 12).

In this study, we aimed to characterize oral status as a potential predictor for future physical weakening in Japanese community-dwelling elderly individuals by performing comprehensive oral examinations. Furthermore, to define accumulated poor oral status as "oral frailty," we determined the longitudinal impact of the baseline accumulation of poor oral status on future physical weakening (new-onset physical frailty, sarcopenia, and disability) and all-cause mortality.

Methods

Setting and Participants

The ethics committee of the University of Tokyo Life Science approved the study protocol (12–8), and informed consent was obtained from all subjects. This study employed data from the Kashiwa study, a prospective cohort study among community-dwelling elderly individuals (≥65 years old). In 2012, 12,000 community-dwelling elderly individuals were randomly selected from the resident registry of Kashiwa, a city where Japanese urban and rural communities intermingle, and asked to participate in the study by mail. A total of 2,044 subjects (1,013 men and 1,031 women) agreed to participate in baseline survey conducted in 2012; they reflected the age and sex distribution in Kashiwa city. We excluded those needing long-term care via the Japanese public long-term care insurance (LTCI) system (13) with cognitive impairment (mini-mental state examination [MMSE] score of ≤18) (14), or a pacemaker.

Baseline Survey and Follow-up

Baseline surveys were conducted in 2012. We assessed oral examination, potential confounders, and baseline physical frailty and sarcopenia. Follow-up surveys regarding new-onset physical frailty and sarcopenia were conducted in 2013 and 2014. Further long-term follow-up surveys for new-onset disability and mortality were conducted from September 2012 to June 2016 since physical frailty is highly likely to affect these outcomes (Supplementary Figure 1).

Measures

Oral examinations

Oral examinations consisted of 16 measures including five dental status, eight oral functions, and three subjective difficulties, the details of which are summarized in Supplementary Methods section. All these measures were assessed by trained dental hygienists with experience of working in clinical practice under the supervision of dentists. All dental staff were trained in workshops. The 16 measures were as follows:

- Dental status: number of natural teeth and functioning teeth, community periodontal index, tongue thickness as a marker of oral nutrient status, and turbidity of mouth-rinsed water as a marker of oral hygiene.
- Oral functions: maximum occlusal force, chewing ability as a marker of general masticatory performance, maximum tongue pressure, repetitive saliva-swallowing test (RSST), three different sounds ("pa," "ta," and "ka"), and oral wettability.
- Subjective assessments: difficulties in eating and swallowing, and experience of dry mouth measured using the questionnaire (15).

Outcomes

Physical frailty and Sarcopenia

Physical frailty was defined according to the Cardiovascular Health Study (CHS) index criteria, based on the following five conditions: shrinking, exhaustion, low activity, weakness, and slowness (16). Participants with none of the five conditions were considered nonfrail, whereas those with one to two conditions were prefrail, and those with three or more conditions were frail (16). Shrinking was defined as unintentional weight loss of ≥2 kg or ≥5 per cent over the previous 6 months (15) and assessed using self-reported weight loss at the baseline survey, with actual weight loss assessed at follow-up (InBody 430 body composition analyzer; Biospace, Seoul, Korea). Exhaustion was measured as a positive answer to either of the following two self-reported questions: "(i) In the last 2 weeks, have you felt tired without a reason? (ii) In the last 2 weeks, have you felt difficulty in doing what you could do easily before?" Low activity was defined as leisure-time activity within the lowest quintile at the baseline assessment and was assessed using the self-reported Global Physical Activity Questionnaire (17). Weakness and slowness were measured using the dominate handgrip strength (Grip D dynamometer; Takei Scientific Instruments Co., Ltd., Niigata, Japan), and usual gait speed (time to walk 5 m) (18), respectively, according to the CHS criteria (16). We also assessed sarcopenia using the criteria and cutoff values of the Asian Working Group for Sarcopenia (3), measured as appendicular muscle mass (InBody 430).

Disability and Mortality

Disability and mortality data were obtained from the LTCI system. Physical independence and survival were assessed at the time of certification for long-term care needs and at the time of death, respectively. New-onset disability was defined as the first point of certification for care needs (LTCI system care level ≥ 3/5) (13).

Covariates

Demographic characteristics, including age, sex, body mass index (BMI), education, living arrangement, yearly income obtained from public data of the city, MMSE score (14), and geriatric depression scale-15 (19), were collected. The presence of diseases, prescribed medications, and biochemical parameters (serum albumin, total cholesterol, and hemoglobin levels) were determined via medical interviews and blood tests. We also assessed dietary and smoking behavior and feelings using a self-reported questionnaire described in Supplementary Table 2.

Statistical Analysis

We performed longitudinal analysis of the association of a poor status in 16 oral measures with physical weakening using a Cox proportional hazard model. We defined poor oral status as being under the lowest quintile of each oral measure or cutoff values from previous studies. Poor oral measures with a p-value of <.100 for all physical outcomes were considered as candidates for oral frailty. The variance inflation factor (VIF) was used to quantify the severity of multicollinearity.

We subsequently assessed the longitudinal association between the accumulated poor status in candidates for oral frailty at baseline and adverse health outcomes (physical frailty, sarcopenia, disability, and mortality) using Cox proportional hazard models.

We calculated the hazard ratios adjusted for potential confounders of adverse health outcomes. In analyses of new onsets of physical frailty and sarcopenia, the hazard ratios were adjusted for potential confounders (20,21), as covariate-adjusted model 1: age, sex, BMI, chronic conditions (hypertension, diabetes mellitus, osteoporosis, dyslipidemia, malignant neoplasm, and chronic renal failure), cognitive function, depressive symptoms, living arrangements, yearly income (> or ≤1.4 million yen), and current smoking status. We excluded from each analysis, participants with physical frailty and sarcopenia at the baseline survey. In analyses for new onset of disability and mortality, the hazard ratios were adjusted for potential confounders of covariate adjusted model 1 and physical frailty at baseline (16), as covariate-adjusted model 2. A bootstrapping method was used to derive the models by correcting the hazard ratios, and 95% confidence intervals for over-optimism. All statistical analyses were performed using IBM SPSS version 24.0 (IBM Japan, Tokyo, Japan). A *p*-value of <.05 was considered statistically significant.

Results

Study Participant Characteristics

Of the 2,044 participants who completed the baseline examination, 33 were excluded for not meeting the inclusion criteria. The cross-sectional comparison between oral health and basic attributes at baseline, and longitudinal analysis of the onsets of disability and mortality were performed for 2,011 participants (50 per cent women; mean age, 73.0 ± 5.5 years). Longitudinal analysis of the onset of physical frailty and sarcopenia was performed for 1,381 participants who completed the follow-up examinations. There were no significant differences between the excluded and included participants in terms of their basic attributes (data not shown).

Oral Health Conditions as a Potential Risk Factor for Physical Outcomes

In the longitudinal analysis regarding new-onset physical frailty among 1,318, we excluded those who presented with baseline physical frailty (n = 151) and missing with new-onset status (n = 79). Similarly, in the analysis regarding new-onset sarcopenia, we excluded those who presented with baseline sarcopenia (n = 113) and missing with new-onset status (n = 52). Over the first 24 months alone, 7.2 per cent of 1,151 participants had new-onset physical frailty, and 5.2 per cent of 1,216 participants experienced new-onset sarcopenia.

Over the 45-month follow-up period, 4.5 per cent of the 2,011 participants experienced subsequent disability. Among the 16 oral measures assessed at baseline, six can lead to candidates for oral frailty because of *p*-values <.100 for all physical outcomes (Table 1). These six measures included the following: (i) the number of natural teeth, (ii) chewing ability, (iii) articulatory oral motor skill for "ta," (iv) tongue pressure, (v) subjective difficulty

Table 1. Longitudinal Association of Oral Health With New Onsets of Physical Outcomes

	Physical frailty			Sarcopenia			Disability: LTCI care level ≥3/5		
Baseline oral condition	not onset	onset	*p**	not onset	onset	*p**	not onset	onset	*p***
Number of participants	1,068	83		1,153	63		1,922	89	
Dental status									
Number of remaining teeth (<20)	**31%**	**38%**	**.052**	**31%**	**41%**	**.041**	**30%**	**59%**	**.005**
Number of functioning teeth (<$Q_{1/5}$: 26)	14%	15%	.619	14%	14%	.843	14%	17%	.758
Tongue thickness, mm (<$Q_{1/5}$: M, 4.48; W, 4.36)	19%	16%	.261	20%	18%	.691	20%	12%	.113
CPI (>2 maximum CPI score)	74%	64%	.124	73%	81%	.272	74%	75%	.760
Turbidity of mouth-rinsed water (>$Q_{4/5}$: M, 0.39; W, 0.48)	19%	25%	.329	19%	13%	.226	20%	24%	.702
Oral function									
Maximum occlusal pressure, N (<$Q_{1/5}$: M, 275; W, 233)	19%	29%	.017	20%	26%	.221	19%	32%	.066
Chewing ability (<$Q_{1/5}$: M, 14.2; W, 10.8)	**18%**	**25%**	**.047**	**18%**	**26%**	**.070**	**19%**	**28%**	**.006**
RSST (<3 times swallowing saliva/ 30 sec)	34%	42%	.370	35%	36%	.790	34%	43%	.592
Articulatory oral motor skill, times/s									
"pa"(<$Q_{1/5}$: M, 5.2; W, 5.6)	18%	26%	.321	17%	21%	.791	17%	23%	.354
"ta"(<$Q_{1/5}$: M, 5.2; W, 5.4)	**16%**	**29%**	**.021**	**16%**	**27%**	**.083**	**15%**	**22%**	**.011**
"ka" (<$Q_{1/5}$: M, 4.4; W, 5.0)	16%	20%	.598	14%	14%	.554	17%	19%	.637
Tongue pressure, kPa (<$Q_{1/5}$: M, 27.4; W, 26.5)	**19%**	**26%**	**.037**	**19%**	**30%**	**.039**	**19%**	**28%**	**.051**
Oral wettability (<3 mm classified as dry mouth)	35%	38%	.702	35%	28%	.111	35%	35%	.323
Subjective measures									
Difficulties eating tough foods (yes)	**16%**	**26%**	**.005**	**15%**	**29%**	**.007**	**15%**	**22%**	**.034**
Difficulties in swallowing on tea or soup (yes)	**20%**	**25%**	**.094**	**20%**	**26%**	**.078**	**18%**	**23%**	**.036**
Experience having a dry mouth (yes)	27%	44%	.003	27%	30%	.651	27%	29%	.510

Notes: CPI = Community periodontal index; LTCI = long-term care insurance; M = men; $Q_{1/5}$ = the first quintile; $Q_{4/5}$ = the fourth quintile; RSST = repetitive saliva swallowing test; W = women.

Bold typeface indicates $p < .100$ in all analyses.

**p*-Values adjusted for covariate model 1: age, sex, BMI, chronic conditions, depressive symptoms, cognitive function, living arrangement, yearly income, and smoking behavior; participants having baseline outcomes were excluded from each analysis.

***p*-Values adjusted for covariate model 2: model 1 and physical frailty at baseline.

in eating tough foods, and (vi) subjective difficulty in swallowing. We checked the multicollinearity of these measures, none of which showed a VIF of 2.0 for all outcomes. We employed these six measures for comparing the impact of "oral frailty status" in a longitudinal analysis between participants with and without adverse health outcomes.

Oral Frailty

Relative to participants with an oral frailty score of 0/6 at baseline, an oral frailty score of 1 or 2 was associated with an increased risk of physical frailty, and a score of 3 or more was significantly associated with an increased risk of new onset of all three outcomes (see Supplementary Table 1).

We defined oral non-frailty as no poor status in the six targeted measures, oral prefrail status as poor status in 1 or 2 measures, and oral frailty status as poor status in three or more of the six targeting measures. Accordingly, we classified 34 per cent of the participants as orally nonfrail, 50 per cent as orally prefrail, and 16 per cent as orally frail (Table 2 and Supplementary Table 2). Participants with oral frailty were significantly more likely to be older, with a lower level of education, yearly income, cognitive function, BMI, serum albumin, and a higher prevalence of physical frailty and sarcopenia at baseline, higher depressive score, and take more medications. However, no significant association was found between chronic conditions and oral frailty.

Furthermore, participants with oral frailty were significantly more likely to have a lower meal volume, decreased meat intake because of a difficulty in chewing, slower eating speed, loss of appetite, feelings of boredom during their meal, and eat alone.

Independent Contribution of Oral Frailty to Geriatric Outcome Risk

Over the 45-month follow-up period, 3.2 per cent of the participants died. The hazard ratios of physical frailty, sarcopenia, disability, and mortality based on oral frailty status are shown in Table 3. The Cox proportional hazards models revealed that participants with oral frailty were at significantly increased risks of experiencing all outcomes. Survival curves for mortality estimates adjusted for covariates are shown in Figure 1. There was a significant difference in the incidence of mortality between the orally frail and prefrail (hazard ratio, 1.99; 95% confidence interval, 1.14–3.57; $p < .022$). The definition of oral frailty used in the present study was therefore a strong predictor of adverse health outcomes including mortality.

Discussion

In this study, we investigated physical, mental, and social factors affecting community-dwelling elderly individuals, to identify whether poor oral status affected risks for physical weakening, and to examine whether accumulation of oral frailty could predict adverse health outcomes. Our results suggest that poor status in six oral measures may potentially predict new onsets of physical frailty, sarcopenia, and subsequent requirement for long-term care (Table 1). Our results also demonstrate that baseline oral frailty status, as defined using these six measures, significantly predicted susceptibility to physical frailty, sarcopenia, the subsequent need for LTCI, and mortality, although there was no significant association between oral frailty status and chronic conditions at baseline (Tables 2 and 3).

Previous studies have suggested that impaired oral health is significantly associated with the pathogenesis of frailty, which suggests a

Table 2. Baseline Demographic and Background Characteristics According to Oral Frailty Status

	Overall		Baseline oral frailty status						Age adjusted trend p
			Non frail (0/6)		Pre frail (1–2/6)		Frail (≥3/6)		
Number of participants	2011		689	(34%)	1003	(50%)	319	(16%)	—
Basic attributes									
Age, y	73.0	(±5.5)	71.2	(±4.5)	73.2	(±5.5)	76.2	(±6.0)	<.001
Sex, women	1017	(51%)	323	(47%)	531	(53%)	163	(51%)	.077
Education, y	12.7	(±2.8)	13.2	(±2.6)	12.5	(±2.8)	12.0	(±2.9)	<.001
Living alone	224	(11%)	58	(8.4%)	124	(12%)	42	(13%)	.311
Yearly income (≤1.4 million yen)	1163	(58%)	364	(53%)	597	(60%)	202	(63%)	.001
Physical conditions									
Body mass index, kg/m^2	22.9	(±3.0)	23.1	(±2.9)	22.9	(±3.1)	22.5	(±3.0)	.031
Cognitive function	28.2	(±1.8)	28.4	(±1.6)	28.2	(±1.8)	27.8	(±2.0)	.010
Depressive symptoms, ≥6 GDS-15	302	(15%)	107	(16%)	139	(14%)	56	(18%)	.412
GDS-15 score	2.66	(±2.9)	2.00	(±2.5)	2.80	(±3.0)	3.70	(±3.3)	<.001
Sarcopenia	118	(5.9%)	12	(1.7%)	68	(6.8%)	38	(12%)	<.001
Physical frailty	170	(8.5%)	25	(3.6%)	80	(8%)	65	(22%)	<.001
Present chronic conditions									
Hypertension	884	(44%)	259	(38%)	467	(47%)	158	(50%)	.064
Diabetes mellitus	243	(12%)	77	(11%)	124	(12%)	42	(13%)	.381
Osteoporosis	226	(11%)	5	(0.7%)	5	(0.5%)	5	(1.6%)	.336
Dyslipidemia	771	(38%)	273	(40%)	382	(38%)	116	(36%)	.056
Malignant neoplasm	303	(15%)	96	(14%)	151	(15%)	56	(18%)	.775
Heart disease	353	(18%)	101	(15%)	182	(18%)	70	(22%)	.086
Chronic renal failure	15	(0.7%)	57	(8.3%)	119	(12%)	50	(16%)	.264
Comorbidity, ≥2 chronic conditions	876	(44%)	255	(37%)	461	(46%)	160	(50%)	.118
Number of prescript medications	2.97	(±3.1)	2.30	(±2.6)	3.12	(±3.0)	3.89	(±3.7)	<.001

Note: GDS-15 = geriatric depression scale-15.

Table 3. Baseline Oral Frailty Status Predicting New Onsets of Physical Frailty, Sarcopenia, Disability, and Mortality

Outcomes	Overall	Baseline oral frailty status		
		Non-frail (0/6)	Pre-frail (1–2/6)	Frail (≥3/6)
Physical frailty	*N* = 1,151			
2-year-incidence	% = 7.2	% = 3.5	% = 8.8	% = 12
Unadjusted		HR = 1.00	HR = 2.44 (1.41–4.20) *p* = .001	HR = 3.66 (2.55–7.51) *p* < .001
Covariates-adjusted†		HR = 1.00	HR = 1.85 (1.06–3.23) *p* = .031	HR = 2.41 (1.27–4.55) *p* = .007
Sarcopenia	*N* = 1,216			
2-year-incidence	% = 5.2	% = 2.2	% = 5.8	% = 11
Unadjusted		HR = 1.00	HR = 2.42 (1.27–4.62) *p* = .007	HR = 4.52 (2.19–9.30) *p* < .001
Covariate-adjusted†		HR=1.00	HR=1.85 (0.95–3.58) *p* = .070	HR=2.13 (1.05–4.58) *p* = .032
Disability: LTCI care level ≥3/5	*N* = 2,011			
45-month-incidence	% = 4.5	% = 1.5	% = 5.6	% = 7.0
Unadjusted		HR = 1.00	HR = 3.94 (2.01–7.72) *p* < .001	HR = 5.30 (2.52–11.1) *p* < .001
Covariate-adjusted‡		HR=1.00	HR=1.88 (0.86–4.10) *p* = .115	HR=2.35 (1.18–4.67) *p* = .015
Mortality	*N* = 2,011			
45-month-incidence	% = 3.2	% = 1.9	% = 3.1	% = 6.3
Unadjusted		HR = 1.00	HR = 1.64 (0.86–3.14) *p* = .133	HR = 3.36 (1.67–6.75) *p* = .001
Covariate-adjusted‡		HR = 1.00	HR = 1.22 (0.63–2.39) *p* = .554	HR = 2.09 (1.00–4.35) *p* = .048

Notes: 95% CI = 95% confidence interval; HR = hazard ratio; LTCI = long-term care insurance; N = number of participants included in the analysis.

†Adjusted model 1 included as baseline covariates: age, sex, BMI, chronic conditions, depressive symptoms, cognitive function, living arrangement, yearly income, and smoking behavior; participants having baseline outcomes were excluded from each analysis.

‡Adjusted model 1 included as covariates: model 1 and physical frailty at baseline.

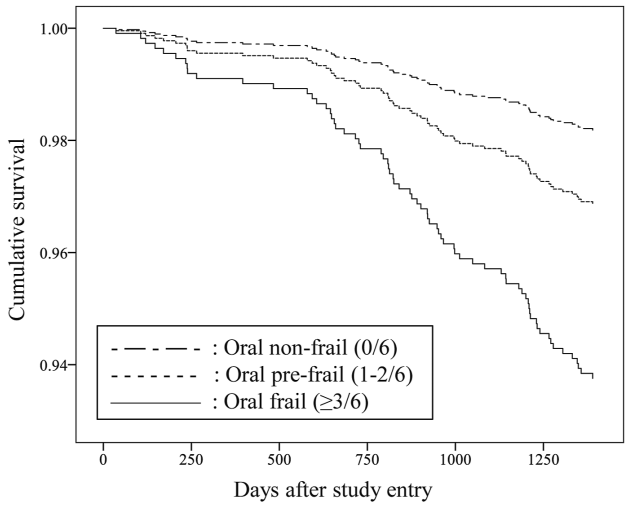

Figure 1. Survival curves for all-cause mortality estimates over 45 months of follow-up according to oral frailty status at baseline. Each curve was adjusted for age, sex, body mass index, cognitive function, depressive symptoms, living arrangements, yearly income, smoking behavior, chronic conditions, and baseline physical frailty.

multidimensional geriatric syndrome (6,7). Impaired oral health, for example, tooth loss and subjective difficulties in eating directly, leads to physical decline and functional disability, and contributes to frailty. Previous studies also reported an association between oral functions and physical conditions. Low masticatory ability is associated with weaker physical performance (22), sarcopenia (23), and mortality (24), whereas low tongue pressure is significantly associated with frailty in elderly individuals (25) and reflects dysphagia (26). Swallowing or chewing problems, and poor oral intake, increased the likelihood of weight loss, contributing to frailty (27). In addition, a low occlusal force, masseter muscle thickness, and low articulatory oral motor skill have been cross-sectionally associated with frailty, as defined by the CHS index (7). These findings suggest that impaired oral function, and not only functional tooth loss, could be associated with frailty status because the six measures identified could indicate increased risks of frailty. Our results were similar and showed that oral frailty status is linked with higher frequencies of habitual inadequate food intake, worsened nutritional status, and higher prevalence of physical frailty and sarcopenia at baseline. Some large-scale studies have reported that a low number of natural teeth was associated with disability (9) and mortality (10), whereas poor chewing ability was associated with the need for long-term care (28). These studies did not assess the increased risk of physical frailty, but our results suggest that oral frailty could have a strong impact on long-term care needs, disability, and mortality, because it directly increases vulnerability to physical frailty, including sarcopenia.

Longitudinal analysis revealed that accumulated poor status in six oral measures could predict adverse health outcomes. These oral measurements consisted of multifaceted functions, because tongue pressure represents a person's nutritional status and swallowing ability, whereas articulatory oral motor skill represents a person's oral dexterity. Subjective difficulties in swallowing and eating were significantly associated with an increased risk of physical frailty, although the objective swallowing function assessed using RSST

was not. Possibly, subjective difficulties in eating and swallowing are more likely to be related to habitual poor food intake than objective measures. In fact, a previous study reported that both subjective and objective assessments should be undertaken (29). Because most oral frailty components, except the number of teeth, were reversible, early awareness of declining oral health and prompt treatment of impaired oral function may be effective in preventing adverse health outcomes. Firstly, preventing tooth mortality is essential. The preventive effects of education in oral self-care and professional mechanical tooth cleaning on tooth mortality have been recognized (30). Furthermore, an oral health education program, including an exercise for promoting oral functions, was shown to be effective in improving articulatory oral motor skill (31,32), functional performance of the tongue (31), and swallowing function among disability-free elderly individuals (31,32). These programs could be useful for improving chewing ability and subjective difficulties in eating because occlusal force and self-reported masticatory ability are also likely to be improved (32). Taken together, oral frailty could be prevented by proper oral self-care, habitual exercise for oral functions, and periodic professional checkups, which requires evaluation.

Limitations

This study has multiple limitations. We only assessed general mortality, and thus the cause of death was unknown. Second, the 16 oral measures were comprehensive and each measure was valid by previous reports; however, unobserved oral measures might provide different results from this study. Third, the oral frailty status concept was developed using a single study population. Fourth, although we calculated hazard ratios that were adjusted for confounding factors in all analyses, some biases may have remained because of unobserved measurements. Fifth, the low-response rate might provide biased results, although participants were randomly selected from the resident register and reflected the distribution of age in Kashiwa city for each sex.

Conclusions

This longitudinal study evaluated whether multifaceted oral health and its accumulated poor conditions could predict adverse health outcomes including mortality in community-dwelling elderly individuals. The results demonstrated that accumulation of a slightly poor status in oral conditions (i.e. oral frailty) strongly predicted physical frailty, sarcopenia, need for long-term care, and mortality. This finding implies that it is extremely important to raise awareness of oral frailty and to strengthen oral health-related literacy to promote healthy aging. Finally, evaluating multifaceted oral health conditions and treating problems early on could lead to a significant paradigm shift in health management.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of interest statement

None declared.

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