ASSOCIATION BETWEEN NUMBER OF TEETH, DENTURE USE AND FRAILTY: FINDINGS FROM THE WEST CHINA HEALTH AND AGING TREND STUDY

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Abstract: *Objective:* Frailty and poor oral health are both common age-related conditions. However, the association between oral health and frailty has not been explored thoroughly among older Chinese adults. We aimed to investigate the associations between number of teeth, denture use, and frailty among older adults in western China. *Design:* Cross-sectional study. *Setting:* Community-based. *Participants:* Participants were 4037 community-dwelling individuals aged 60 and older from the West China Health and Aging Trend (WCHAT) study. *Measurements:* Frailty was assessed using the physical frailty phenotype (PFP) and categorized as non-frail, prefrail and frail. In addition, number of teeth and denture use were examined by calibrated dentists. Multinomial logistic regression models were performed to examine the association between number of teeth, denture use, and frailty. *Results:* The overall prevalence of frailty was 6.7% among 4037 participants aged 60 and older in western China. Participants with no more than 20 teeth were associated with higher odds of being prefrail or frail whether wearing dentures or not. Denture using could not help lower the odds of being prefrail or frail for older adults with fewer teeth. *Conclusions:* This study suggested that frailty was associated with having fewer teeth (≤20 teeth) among older Chinese adults. Future research involving targeted interventions addressing number of teeth may help provide information to establish effective strategies for frailty prevention in older adults.

Key words: Frail elderly, oral health, tooth loss, dentures.

Introduction

Frailty is an age-related clinical condition characterized as increased vulnerability and decreased resilience to stressors (1-3). Frailty is prevalent among older adults, the overall prevalence of frailty was reported to be 7.0% in China, according to the China Health and Retirement Longitudinal Study (CHARLS) (4). Frail older individuals are more predispose to adverse outcomes such as disability, hospitalization or even death (5), and less likely to recover from internal and external stressors (6, 7). With the arrival of aging society, it will undoubtedly place an increasing burden on health resources, and there is increasing demands for identifying risk factors and effective interventions for frailty (8). In the process of exploring the contributors of frailty, it was found that varieties of factors are associated with frailty, such as increasing age (9), malnutrition (10), inflammation (11), and depression (12).

Poor oral health, a common condition among older adults, has been reported to be associated with general health and greater risks of being frail (13-15). A number of studies have focused on exploring the link between oral health and frailty. For example, a longitudinal study from Japan has found a significant association between accumulated oral health problems (including tooth loss, periodontal disease and subjective assessments) and higher risk of frailty in older ages (16). A study from Brazil including 1370 community-dwelling individuals aged 60 and older showed that edentulous older individuals were more likely to be frail than persons have more

than 20 teeth, and the need for dentures was associated with frailty as well (17). Tooth loss, as a common manifestation of poor oral health, was reported to be associated with frailty (18, 19). Previous studies suggested that tooth loss could affect chewing ability[20], subsequently lead to malnutrition (21) and contributing to frailty (10). However, dental restoration could help support the impaired function to some extent (20). At present, most studies focused on the association of frailty with number of teeth and denture use separately (17, 18). Few studies have focused on the combined effect of number of teeth and denture use on frailty, i.e., differences in frailty between persons with adequate dentition, those without adequate dentition but wearing dentures, and those have neither adequate dentition nor dentures (22). In addition, few studies have explored the association between number of teeth, denture use and frailty among Chinese older adults.

In this study, we aimed to investigate the possible association between number of teeth, denture use and frailty among participants aged 60 years and older in west China. By doing so, we will help to target population that may benefit the most from oral health intervention in order to prevent frailty.

Method

Study population

West China Health and Aging Trend (WCHAT) study was an ongoing, longitudinal study dedicating to promote interdisciplinary research on healthy aging among multi-ethnic population in western China. The study was conducted in 2018,

comprising 7536 community-dwelling individuals aged 50 and older from 18 ethnic groups in Sichuan, Yunnan, Guizhou and Xinjiang province. Multi-stage cluster random sampling was applied in the study, with a response rate of 50.2%. Personal face to face interview was conducted by trained interviewers in a designated hospital of each survey place, together with physical examination, anthropometric measurement and blood sample test. Participants with severe diseases, life expectancy less than six months, those who were unable to complete all the interview and examination independently, or refused to sign the informed consent were excluded from the WCHAT study. For this study, in order to better focus on the condition of the older adults, the study included 4514 participants aged 60 and older. After excluding 370 individuals with missing data on more than two of the 5-criteria of frailty phenotype, and 107 individuals with missing data on number of teeth or denture use condition, the final analysis included 4037 participants. Informed consent was obtained from all individual participants included in the study. This study was approved by the Ethics Committee of West China Hospital, Sichuan University.

Frailty criteria

Frailty was identified by the modified physical frailty phenotype (PFP) scale developed in the Cardiovascular Health Study (5) since the measurements were not identical. The modified criteria were conducted according to the WCHAT interview, and physical performance measures. The five elements were as follows: shrinking, slowness, weakness, exhaustion and low physical activity.

Shrinking: Self-reporting loss of weight for more than 4.5 kg in previous year or body mass index (BMI) <18.5 kg/m^2 (4).

Slowness: Slowness was defined using the 4-meter gait speed test, as being ≤ 20th percentile of the population within four categories classified by sex and sex-specific median height.

Weakness: The bottom quintile of the maximum of the two-timed handgrip strength of dominant hand was identified as weakness within eight categories classified by sex and BMI (<18.5 kg/m^2, low weight; 18.5-23.9, kg/m^2 normal; 24-27.9 kg/m2 , overweight; ≥28 kg/m^2, obese) (23).

Exhaustion: Exhaustion was defined as meeting one or more of three criteria of the following items: 1) Feeling excessively fatigue for most of the time; 2) Feeling excessively weak for most of the time; 3) Self-rated energy level was ≤3, if 10 represents the most powerful condition.

Low physical activity: Low physical activity was identified as being ≤ 20th percentile of energy consumption per week in different gender groups. Energy consumption was measured by a validated China Leisure Time Physical Activity Questionnaire (CLTPAQ) (24) , which was a modified version of the Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ) (25) according to the Chinese lifestyle and cultural background.

Note: Energy consumption (kcal /week) = MET * Times per week * Minutes per time * Weight(kg)/60

Categories of physical activities included walking (4.0 MET), indoor housework (3.5 MET), outdoor housework (5.0 MET), dancing (4.5 MET), playing ping-pong (4.0 MET) and other regular exercises (5.0 MET).

Each item was scored as 1 for meeting the criteria, otherwise scored 0. Participants with score of 3 or more were categorized as frail, those with 1 or 2 score were considered prefrail, and 0 for non-frail.

Explanatory variables

Number of teeth and denture use were examined by calibrated dentists. In each survey place, dental status was checked by two dentists simultaneously in order to ensure consistency. Studies have shown that retention of more than 20 teeth could be accepted as adequate dentition (26, 27), thus participants were divided into three groups determined by the combination of number of teeth and denture use:1) >20 teeth; 2) ≤20 teeth, with dentures; 3) ≤20 teeth, without dentures.

Covariates

To control for potential confounding, a number of socio-demographic and health-related and functional variables were included as confounders. Socio-demographic variables included age, sex, education (illiterate, primary school, secondary school and above), ethnicity (Han, Qiang, Tibetan, Yi, Uighur and others) and marital status (married, and single (unmarried/ widowed/ divorced)). Health-related and functional variables included history of smoking, disability in activities of daily livings (ADL disability), number of chronic diseases and depression. ADL disability was defined as having needs for assistance or difficulty in one or more of the ten items in Barthel Index (28). Number of chronic diseases was categorized as 0, >1 and ≥2, based on the doctors' diagnosis of hypertension, heart disease, lung disease, digestive disease, stroke, diabetes, osteoarthritis and tumor. Depression was evaluated by the GDS-15 scale (29). Individuals with a GDS-15 score of 8 or greater were classified as depression.

Statistical analysis

Descriptive analyses were presented as mean ± SD for continuous variables, and number (percentage) for categorical variables. Differences between groups were tested by ANOVA for continuous variables and Pearson's chi-square test for categorical variables. Multinomial logistic regression analyses were conducted to determine the unadjusted and adjusted association of dental status with frailty. The multivariable adjusted model included socio-demographic variables (age, sex, education, ethnicity, and marital status) and health-related and functional variables (history of smoke, ADL disability, number of chronic disease and depression). Odds ratio (OR) and 95% confidence intervals (CI) were conducted and Z test was used to determine whether the effect was significant.

Stata15.1 (Stata Corp, College Station, TX, USA) was used for statistical analyses. Two-sided p <0.05 was considered

Table 1
Prevalence of Frailty by independent variables, West China Health and Aging Trend (WCHAT) study (n=4037)

Characteristics	Overall n=4037	Non-frail n=1869 (46.3%)	Prefrail n=1898 (47.0%)	Frail n=270 (6.7%)	p-value
Age, mean ± SD	67.8±5.9	66.5±5.0	68.5±6.2	72.3±6.8	<0.001
Sex (n, (%))					0.758
Male	1687	770 (45.6)	801 (47.5)	116 (6.9)	
Female	2350	1099 (46.8)	1097 (46.7)	154 (6.6)	
Education (n, (%))					<0.001
Illiterate	1364	541 (39.7)	699 (51.2)	124 (9.1)	
Primary school	1535	724 (47.2)	732 (47.7)	79 (5.1)	
Secondary school and above	1130	599 (53.0)	464 (41.1)	67 (5.9)	
Ethnicity (n, (%))					<0.001
Han	1517	729 (48.1)	705 (46.5)	83 (5.5)	
Qiang	859	516 (60.1)	323 (37.6)	20 (2.3)	
Tibetan	668	272 (40.7)	327 (49.0)	69 (10.3)	
Yi	369	145 (39.3)	199 (53.9)	25 (6.8)	
Uighur	301	59 (19.6)	188 (62.5)	54 (17.9)	
Others	323	148 (45.8)	156 (48.3)	19 (5.9)	
Marital status (n, (%))					<0.001
Married	3170	1547 (48.8)	1454 (45.9)	169 (5.3)	
Single (unmarried/ widowed/ divorced)	859	317 (36.9)	441 (51.3)	101 (11.8)	
Tooth number and denture use (n, (%))					<0.001
>20 teeth	2222	1221 (55.0)	936 (42.1)	65 (2.9)	
≤20 teeth, with denture	1300	469 (36.1)	698 (53.7)	133 (10.2)	
≤20 teeth, without denture	515	179 (34.8)	264 (51.3)	72 (14.0)	
History of smoke (n, (%))					0.755
No	3150	1452 (46.1)	1483 (47.1)	215 (6.8)	
Yes	853	404 (47.4)	395 (46.3)	54 (6.3)	
ADL disability (n, (%))					<0.001
No	3514	1714 (48.8)	1633 (46.5)	167 (4.8)	
Yes	508	147 (28.9)	258 (50.8)	103 (20.3)	
Number of chronic diseases (n, (%))					<0.001
0	2154	1070 (49.7)	963 (44.7)	121 (5.6)	
1	992	486 (49.0)	455 (45.9)	51 (5.1)	
≥2	881	307 (34.9)	476 (54.0)	98 (11.1)	
Depression (n, (%))					<0.001
No	3799	1801 (47.4)	1766 (46.5)	232 (6.1)	
Yes	221	59 (26.7)	124 (56.1)	38 (17.2)	

SD, standard deviation; ADL, activities of daily living.

Table 2

The association of number of teeth, denture use and frailty according to multinomial logistic regression models, West China
Health and Aging Trend (WCHAT) study (n=4037)

| | Prefrail vs. Non-frail | | | | Frail vs. Non-frail | | | |
| | Unadjusted | | Adjusted[a] | | Unadjusted | | Adjusted[a] | |
	OR 95% CI	p-value	OR 95% CI	p-value	OR 95% CI	p-value	OR 95% CI	p-value
Reference: >20 teeth	Reference	N/A	Reference	N/A	Reference	N/A	Reference	N/A
≤20 teeth, with denture	1.94 (1.68, 2.24)	<0.001	1.39 (1.19, 1.63)	<0.001	5.33 (3.89, 7.30)	<0.001	2.25 (1.58, 3.21)	<0.001
≤20 teeth, without denture	1.92 (1.56, 2.37)	<0.001	1.28 (1.02, 1.61)	0.032	7.56(5.22, 10.94)	<0.001	2.89 (1.89, 4.42)	<0.001

a. adjusted for age, sex, education, ethnicity, marital status, history of smoke, ADL disability, number of chronic disease and depression; OR, odds ratio; CI, confidence interval.

statistically significant.

Results

Sample characteristics

A total of 4037 participants were included in this study. The characteristics of the study population are showed in Table 1. The mean age was 67.8±5.9 years of the study population. The overall prevalence of frailty was 6.7%, with 47.0% prefrail and 46.3% non-frail. The percentage of participants with >20 teeth was 55.0%, and 32.2%, 12.8% for those with ≤20 teeth, wearing or not wearing dentures, separately. Frail and prefrail individuals were older than the non-frail. The prevalence of frailty differed significantly between education levels and ethnicity groups. Participants with ≤20 teeth showed higher prevalence of frailty than persons with > 20 teeth whether using dentures or not. A higher prevalence of frailty was observed in participants who were single (unmarried/ widowed/ divorced), , had ADL disability, and were depressed. The prevalence of frailty among participants with two or more chronic diseases, which is known as comorbidity (30),were 2 times higher than those with none disease or single disease.

Multinomial logistic regression analyses

Table 2 shows the results of multinomial logistic regression analyses. In the unadjusted model, individuals with ≤20 teeth, with (OR=1.94, 95% CI 1.68-2.24) or without dentures (OR=1.92, 95% CI 1.56-2.37) both showed greater odds of being prefrail than those with more than 20 teeth. The association of being prefrail and having ≤20 teeth, with (OR=1.39, 95%CI 1.19-1.63) or without dentures (OR=1.28, 95% CI 1.02-1.61) persisted after controlling for socio-demographic variables and health-related and functional variables.

Comparing to subjects with >20 teeth, denture-users with ≤20 teeth also showed higher odds of being frail (OR=5.33, 95% CI 3.89-7.30). A similar result was yielded when non-denture users with ≤20 teeth (OR=7.56, 95% CI 5.22-10.94) were compared with the control group. The results remained significant in the adjusted model, with an odds ratio of

2.25 (95% CI 1.58-3.21) and 2.89 (95% CI 1.89-4.42) for denture-users and non-denture users with ≤20 teeth separately, comparing with the >20 teeth group.

No statistically significant difference was found in prefrailty or frailty, between the "≤20 teeth, with dentures" group and "≤20 teeth, without dentures" group, when set the former as the reference (data not shown).

Discussion

The purpose of this study was to explore the association between number of teeth, denture use and frailty. The results of this study demonstrated that having fewer teeth, defined as no more than 20, was associated with frailty, regardless of denture use.

The main result of this study highlighted the significant relationship between fewer teeth and higher odds for frailty, which was in consistent with previous studies. For example, a cross-sectional study from Brazil suggested that comparing with the edentulous, participants with 20 or more teeth had a lower chance of being frail (17). Recently, a cross-sectional study from the 2014 wave of Chinese Longitudinal Healthy Longevity Survey (CLHLS) also found that self-reported number of teeth less than 11 was associated with frailty assessed by the frail index (FI) (31). Different from the FI reflecting accumulated deficits, the PFP scale used in the current study assessed frailty from the physiologically based scope of view (5, 32, 33). In addition, objective examination of dental status was conducted in our study, instead of self-reported conditions. Furthermore, the WCHAT study included sizable number of participants of minority ethnical groups living in western China, while the CLHLS study mainly included the Han people, who make up the great bulk of the Chinese population (34). The mean age of the study sample from the 2014 wave of the CLHLS study was older than the WCHAT study as well (84.27±9.92 years vs. 67.8±5.9 years).

The mechanisms linking number of teeth and frailty remain undetermined. One possible mechanism underlying the association between fewer teeth and frailty might be explained by nutritional pathway. Having fewer teeth could

result in change in food preference and limit the intake of essential nutrition, accordingly, would increase the risk of malnutrition (21, 35), which would further result in frail status (10). Furthermore, tooth loss, considered as an indicator of general health (36), was also reported to be associated with lower quality of life (37), inflammation (38), obesity (27), cognition decline (39), esophageal cancer (40), cardiovascular disease and stroke (41). Therefore it would correlate with frailty indirectly by influencing general health or sharing the same pathophysiologic pathways (42).

The current study also found that persons with ≤20 teeth but wearing dentures were more prone to be frail, compared with those having >20 teeth, which may indicate that although use of dentures could help older adults improve masticatory function and other abilities, it cannot replace the function of natural teeth completely. Additionally, the lack of statistically significant difference in prefrailty or frailty between denture-users and non-denture users with ≤20 teeth also indicated that wearing dentures could not help lower the odds of being frail among older adults with fewer teeth. The result was in accordance with some previous studies. A cross-sectional study from Brazil suggested that use of dental prostheses was not associated with frailty, while the need for dentures was (17). Nevertheless, Lee et al found there was no statistically significant difference in frailty between older adults having more than 20 teeth and those with fewer teeth but wearing dentures, and suggested that wearing dentures could be effective compensation against adverse effects from losing teeth, therefore may help lower the odds of being musculoskeletal frail for individuals with fewer teeth (22). We hypothesis that our finding might be due to unsatisfying functionality of dentures. Previous study suggested that denture-users had difficulty chewing or swallowing were associated with malnutrition, frailty and mortality (35). Besides, the type and location of dentures and duration of wearing may affect the function of dental prothesis as well (43, 44). The ill-fitness and quality of denture might be another plausible contributor, for limited medical resources in western China, especially in areas inhabited by ethnic minorities, compared with eastern developed regions (4, 45). However, the current study did not include detailed information about chewing ability and functionality of dentures, further examinations should be added in the follow-up investigations.

Strengths and limitations

The main strengths of this study were the large sample size and its ethnically diverse population. It is also the first time utilizing the PFP scale to examine the association of frailty and the joint effect of number of teeth and denture use among older individuals in China.

The main limitation of our study was the cross-sectional study design, in which may not reflect causal inferences between independent and dependent variables. Furthermore, we only chose one to two cities for each ethnicity, which could lead to inevitable selection bias, more regions and more ethnicity are needed to be included in the future study. In addition, we did not have access to detailed information about chewing ability and functionality of dentures in the present study, further study exploring the association of functionality of teeth (natural and artificial) and frailty would be informative.

Conclusions

Having fewer teeth (≤20) was associated with higher odds for frailty, regardless of denture use. Wearing dentures could not help completely make up the defect of tooth loss. Chewing ability, functionality of dentures should be taken into account in future studies focusing on association between dental status and frailty. Further studies focusing on effective interventions to restore the remaining teeth are needed for the prevention of frailty.

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